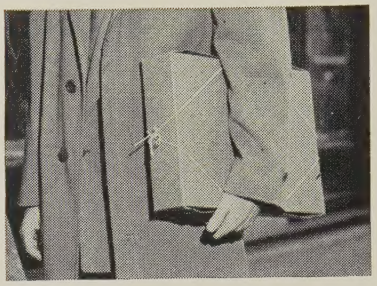
Tappi

PUBLISHED BY THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

JUNE 1952



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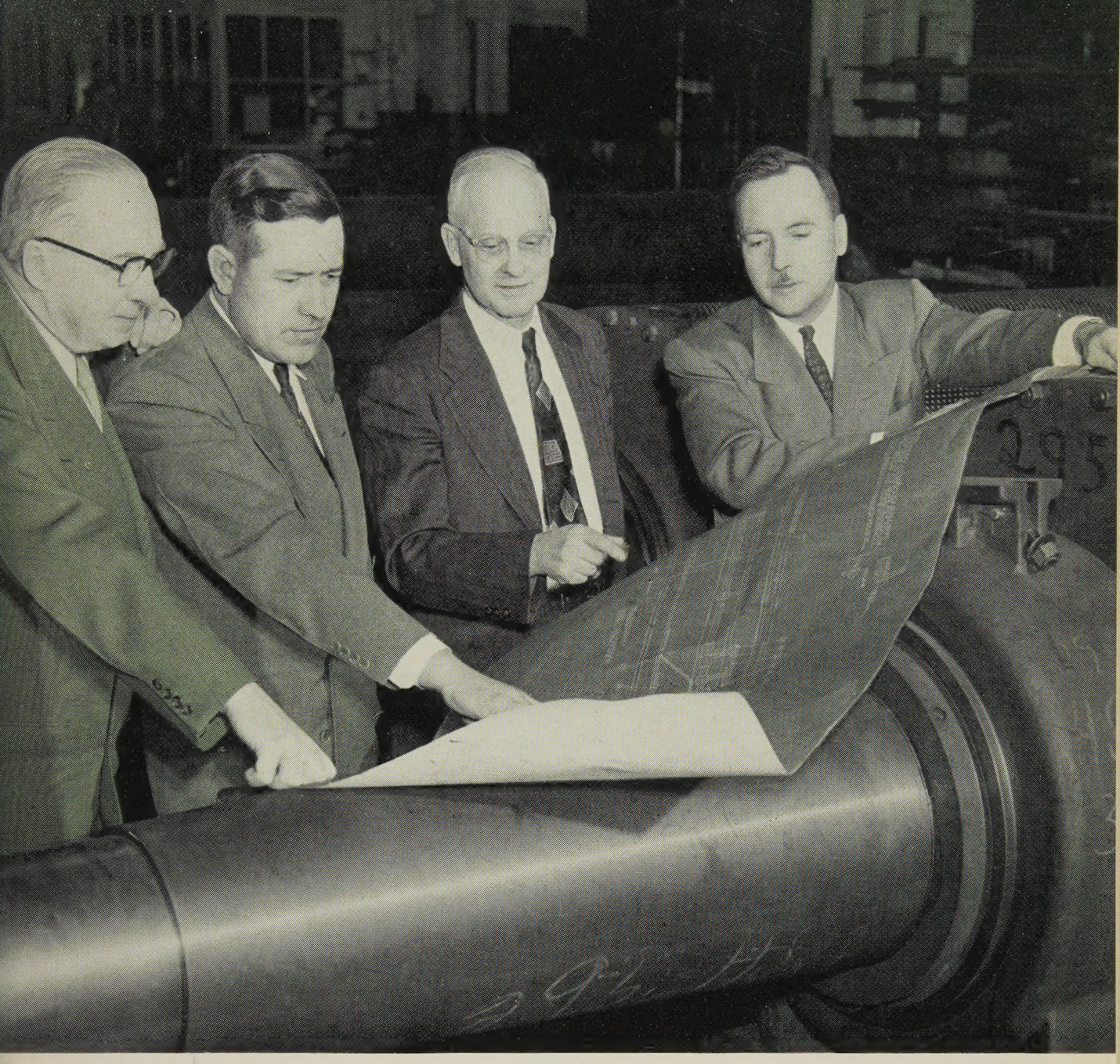

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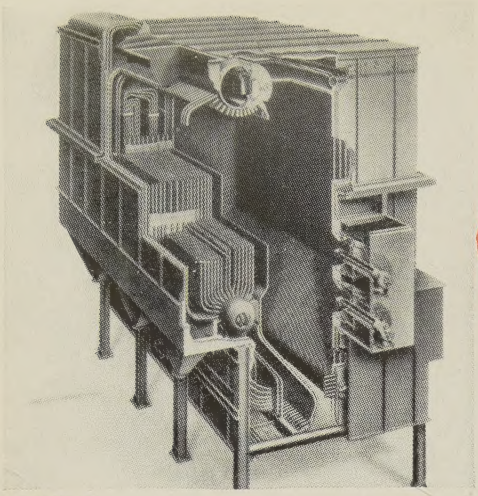

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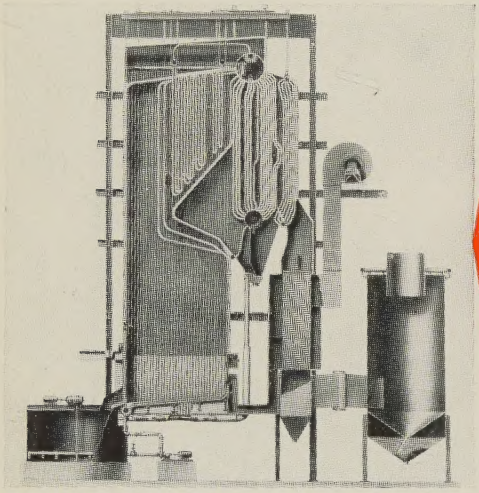

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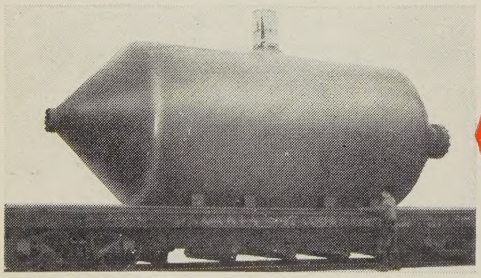

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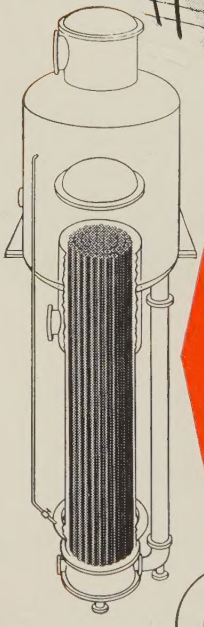

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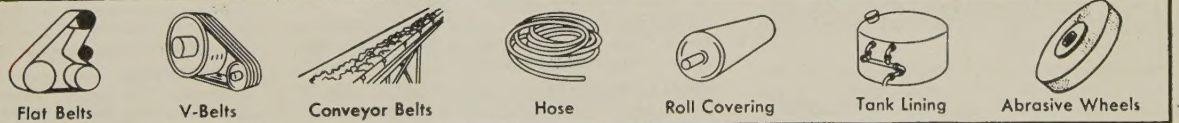

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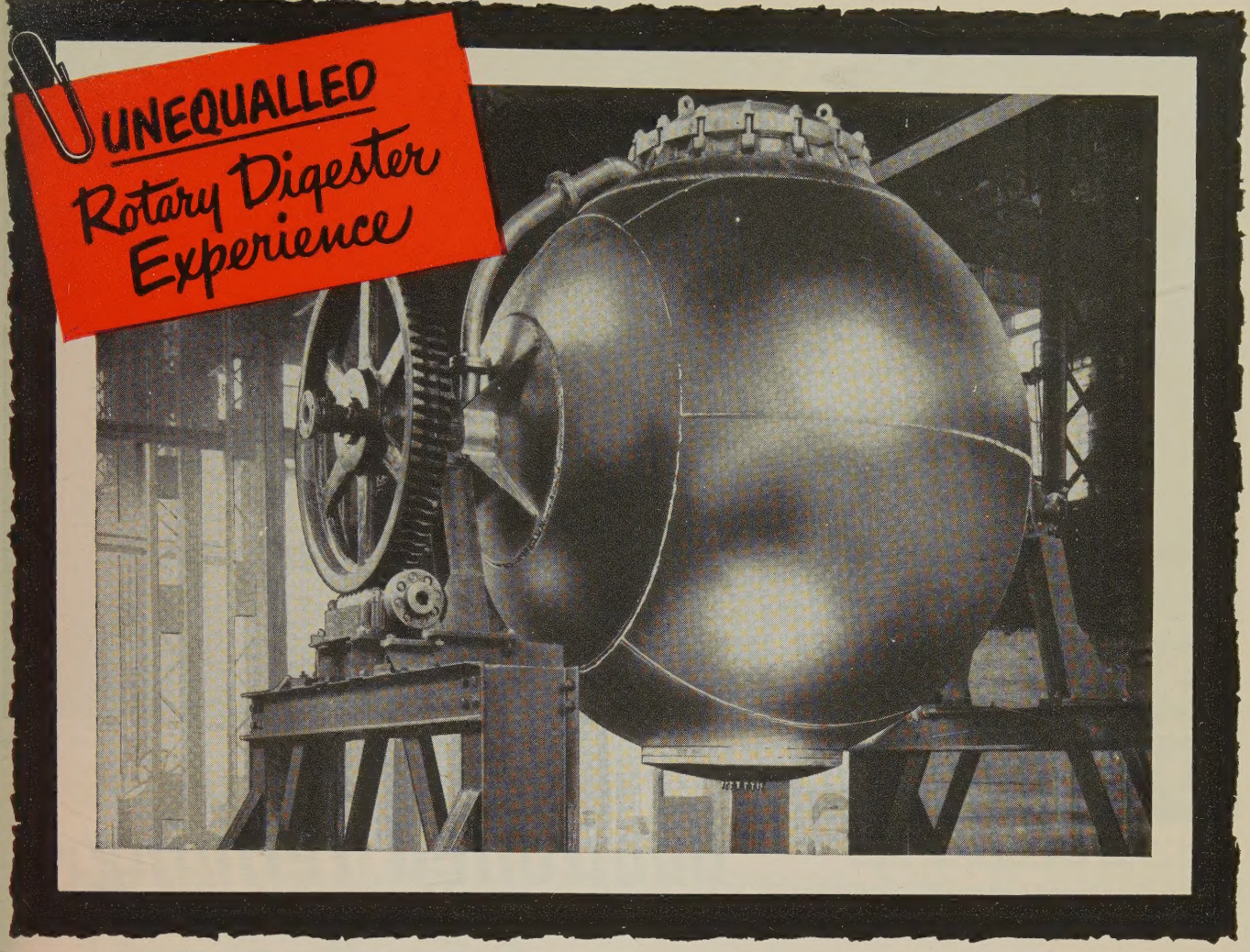

Biggs pressure vessels meet all paper industries requirements

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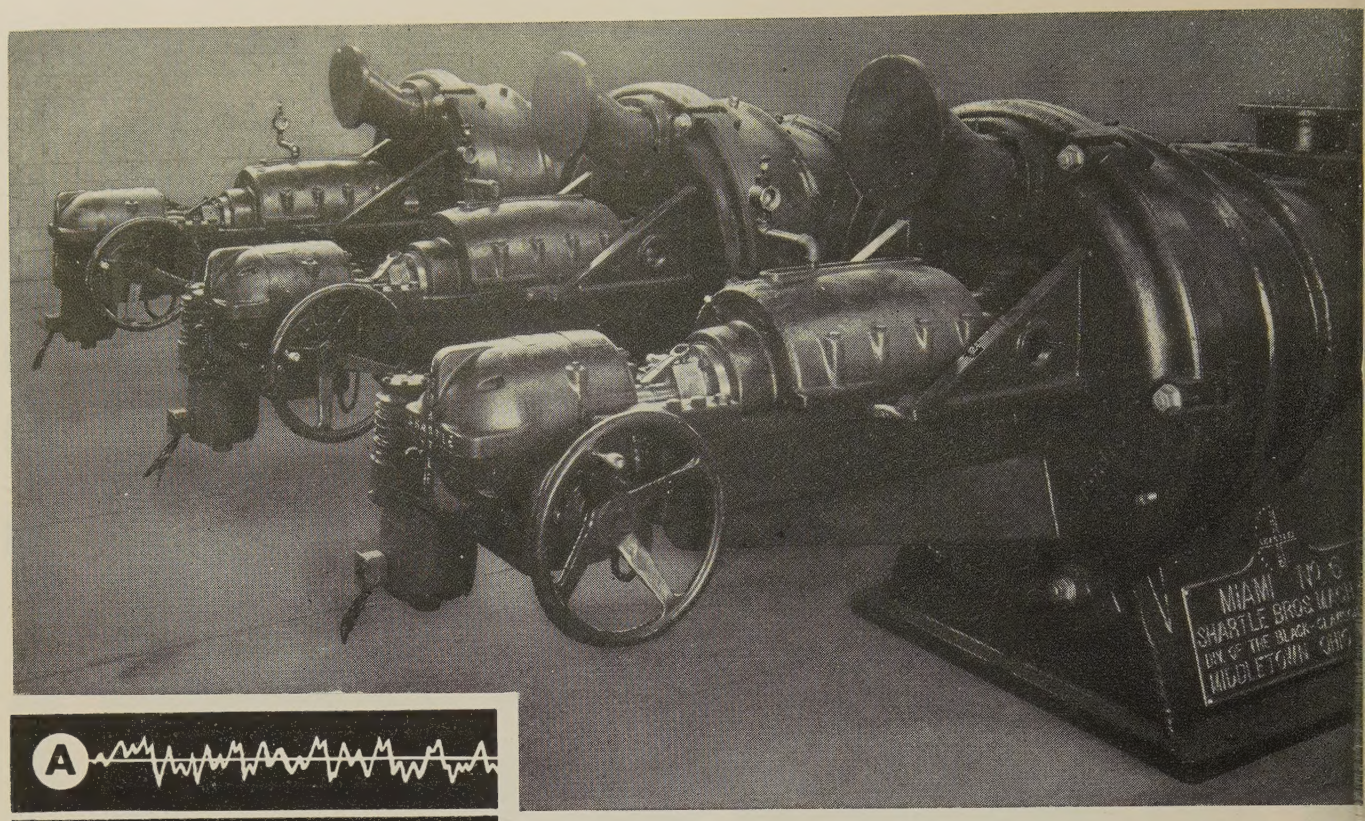
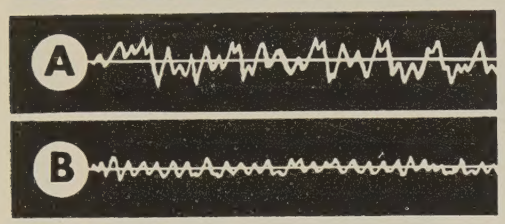


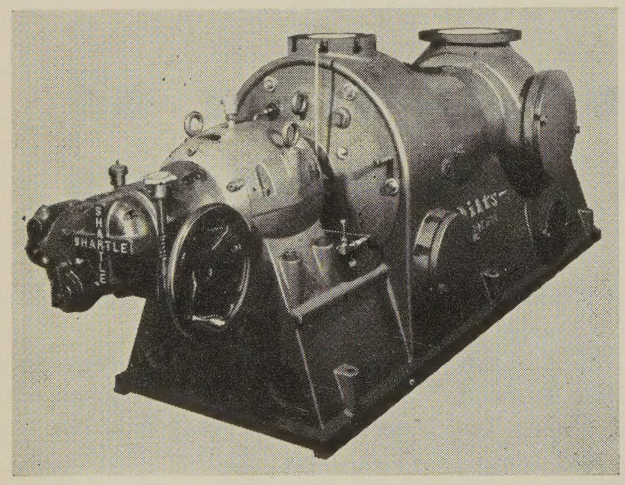
Duotrol on jordans



Jagged line A suggests irregular treatment of stock—when plugs are periodically reset by hand.

More even line B suggests far more uniform treatment—when automatic Duotrol plug adjusters are employed.

duotrolled refining



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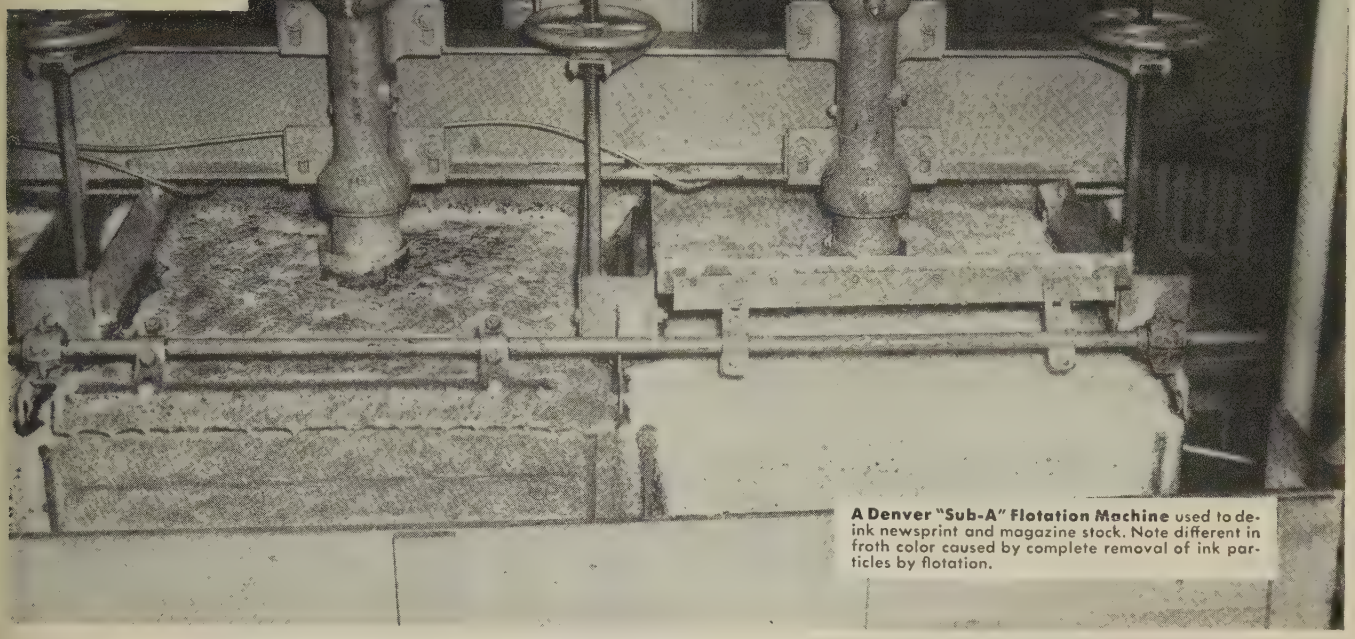

A Denver "Sub-A" Flotation Machine used to de-ink newsprint and magazine stock. Note different in froth color caused by complete removal of ink particles by flotation.

What you should know about Denver "Sub-A" Flotation and how it will work for you...

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Denver "Sub-A" Flotation* is a separatory process. Materials with different surface, physical or chemical characteristics can be separated from each other by flotation. Tiny air bubbles seek out and attach themselves to certain particles and then float to the surface.

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RESULT: Greater brightness ... Less shrinkage ... considerably less water ... and substantially lower chemical costs compared to conventional reclamation systems.

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The European Pulp and Paper Industry Moves Ahead

JOSEPH. E. ATCHISON

It is indeed a great pleasure to be with you this evening. I am particularly pleased to see so many of my old friends from both the United States and European industry gathered here together in a congenial and cooperative spirit. While I am here, I want to take this opportunity to extend to you my belated thanks for the excellent support which all of you have given the Marshall Plan, the Mutual Security Program, and the pulp and paper industry of Free Europe.

When Mr. Juckett first asked me to talk to you this evening, I intended to confine my remarks principally to the important pulp and paper investment program which the ECA and the MSA have supported in Austria. However, in thinking over the progress which has been made in the entire European pulp and paper industry during the past four years, I concluded that the accomplishments of the Marshall Plan countries as a whole should not be neglected. Therefore, before discussing the Austrian program, I should like to give you some background information on our over-all program.

The general purposes and the great accomplishments of the Marshall Plan are well known to all of you. Its objective was the rehabilitation of Europe—a tremendous objective. Thus it was a recovery program, and as such, it proved a tremendous success.

You are also familiar with the Mutual Security Agency (MSA). This agency was created by Congress as a global agency, successor to the ECA, with equal responsibilities in Asia and Western Europe for building up the strength of the free world.

You will be interested in knowing that the pulp and paper industry has played a major role in the entire European recovery effort. It continues to play an important part in our effort to strengthen the defense of the free world.

I want to tell you about some of the developments in the European industry during these past four years, the enormous problems which it has faced, the progress which it has made in solving these problems, and some of the plans for the future. In order to appreciate the phenomenal progress which this industry has made in four short years, we must take a look at conditions as they existed in 1947, the year before the Marshall Plan began.

In 1947, two years after World War II had ended, a large portion of the European pulp and paper industry was in the doldrums. Many mills had been destroyed and were still in ruins, many machines had been limping along for years without repairs or much needed maintenance supplies, a large portion of the machinery was either worn out or antiquated; there were severe shortages of pulpwood, coal, and power; much of the transportation system was still almost paralyzed, and capital for modernization and new investment was almost nonexistent in most of the countries.

Joseph E. Atchison, Chief, Pulp and Paper Branch, Mutual Security Agency, Washington, D. C.

As if these problems were not enough, the Europeans found that a tremendous proportion of their prewar pulp and paper raw materials and production facilities had been cut off behind the Iron Curtain.

As a consequence of the war, Finland lost 25% of her wood pulp capacity (500,000 short tons) and Germany lost about 64% (1,750,000 short tons) of her capacity in the zones being administered by the Soviet Union and Poland. In addition, more than 1,000,000 cords of pulpwood per year which had formerly flowed from Russia and the Baltic countries to the mills of Western Europe were no longer available.

Now, when we add this loss of pulpwood imports to the loss of pulp production, it is not difficult to understand some of the reasons for pessimism existing in the European industry in 1947.

When ECA began operations in early 1948, a pulp and paper committee was established by the OEEC (Organization for European Economic Cooperation) in Paris. This committee was composed of top industry executives and government officials from all of the Marshall Plan countries. An American pulp and paper expert from the ECA office in Paris also sat in on these meetings. The committee immediately set about the task of studying the over-all problems of the European industry. It soon became evident to them, and to us in ECA, that neither mill facilities nor raw materials were adequate in Western Europe to meet the essential demands for pulp, paper, and paperboard.

Since those early meetings in 1948, we have been considering all possible methods of solving the many problems facing the industry. Right here I would like to point out that it is the Europeans themselves who must carry the ball if any real lasting accomplishments are to be made in solving their problems. This they are doing. They are attacking the problems on all fronts, through the OEEC pulp and paper committee, through their own government, and through the efforts of each individual mill. We in ECA, and now in MSA, merely advise, suggest, help in any way possible and, in some instances, provide the dollars which are absolutely necessary.

These problems have been considered from both a short term, and a long term standpoint. From the short term standpoint, the most logical solution involved shipment of pulpwood, pulp, and paper from the Western Hemisphere to fulfill Europe's most urgent requirements. Since April 1, 1948, we have allocated $128,000,000 for the purchase of pulpwood, pulp, and paper in the United States and Canada. During the first year of operations, these allocations amounted to more than $68,000,000; during the second year they totaled about $30,000,000; during the third year about $20,000,000 and during the past year about $10,000,000.

This is progress, gentlemen. It shows a significant trend toward recovery of the European pulp and paper

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For Testing and Developing
Methods of Improving
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industry and less dependence upon United States aid. Of course, as the Europeans are able to increase their own dollar earnings by sales of their goods and services to the United States and Canada, this dollar aid will continue to decrease until it ends entirely.

It is significant that exports of pulp and paper during 1951 from the United States and Canada to Europe reached record levels, yet all but a small portion of these exports were paid for with earned dollars, rather than aid dollars.

These early shipments of raw materials and semi-finished products enabled the European companies to get their mills running. Perhaps, even more important, by sale of their products they were able to begin building capital with which they could improve their mills, rehabilitate and replace machinery, and increase production gradually to prewar levels. Most of them ploughed every cent of profit back into their mills. At the same time other sectors of industry also progressed by leaps and bounds. Coal production increased, pulpwood production was brought up to a maximum, power output was expanded, machinery companies surpassed prewar production levels, and the transportation system was improved. Industry began to hit its stride.

This process continued so that, in spite of tremendous difficulties the industry in Western Europe as a whole surpassed prewar production levels during 1951 for almost all grades of pulp, paper, and paperboard. Production of all grades of paper and paperboard reached almost 11,000,000 short tons in 1951 as compared to 9,500,000 tons before the war. Table I indicates the progress which has been made in production and per capita consumption.

Table I. Trend of Production and Consumption of Pulp and Paper in Marshall Plan Countries

	Total production of wood pulp, short tons	*Total production of paper and paperboard, short tons*	*Over-all average per capita consumption, pounds per year*
Av. 1935–38	6,967,000	9,500,000	80
1947	5,031,000	6,090,000	45
1951	7,655,000	11,000,000	76

However, I want to point out that the production figures alone are somewhat misleading. It must be remembered that the population has also increased from 248,000,000 in 1938 to 276,000,000 in 1951. Therefore, the per capita consumption of paper and paperboard for Western Europe as a whole was only 76 pounds during 1951 as compared to 80 pounds per capita before the war. During that same period of time, United States consumption has almost doubled, rising to almost 400 pounds per capita in 1951.

We are all proud of the progress which has been made on the short term program. However, it was obvious even in 1948 that the long term program would have to provide for greatly increased demands far beyond the levels of prewar days. It is in the long term program that ECA and MSA have played a significant role. Every possible source of fibrous raw material must be exploited if Europe is to meet the potential demand for pulp and paper. We are making efforts to provide facilities for utilization of all of these materials. In addition to softwood, these fibrous materials are hardwoods, straw, esparto, and wastepaper.

The first step in the program involves maximum utilization of softwoods. Actually there are very few countries in Western Europe which have sufficient softwoods to support pulp mill expansion.

The most spectacular example of this approach is the investment program in Austria. The rich forests and the great number of rapidly moving streams available in Austria have provided ideal conditions for the development of a large pulp and paper industry. As a result of these material advantages, the industry has grown to occupy a top position in the economy of the nation.

However, the economic and political conditions prevailing in Austria during the past 20 years have made it impossible for the industry to keep pace with the rapid developments taking place in the pulp and paper industries of other countries. As a result, most of the mills became hopelessly obsolete and by 1949 it was obvious that a tremendous modernization program was absolutely necessary if the Austrian industry was to maintain and expand its important position in Europe as a major supplier of paper and pulp.

A complete survey was made of the entire industry including a careful estimate of the maximum production which could be supported by the available and potential pulpwood supply. It was soon realized that the potentialities were very great if an adequate investment program were vigorously carried out.

In addition to providing Europe with much needed supplies of pulp and paper, the benefits to the Austrian economy appeared to be tremendous This was particularly true with regard to the potential foreign currency earning capacity.

Toward the latter part of 1949, our ECA Mission to Austria, our Paris Headquarters, and our ECA office in Washington all urged the Austrian industry to work out a comprehensive modernization and rationalization program. Thus after a period of long years of forced inactivity, the Austrian industry, with the aid of ECA, had an opportunity to carry out a far-reaching program. Such a comprehensive program was presented by the industry in December, 1949.

The entire program was studied thoroughly by the Mission and by our experts from both Paris and Washington. In addition, three outstanding United States pulp and paper production men spent one month in Austria making an investigation of all of the major projects in which ECA was involved. I am very glad to see one of these men here tonight, Vance Edwardes, whom you all know. Vance was accompanied by K. O. Elderkin, the General Manager of the Crossett Paper Mills, and James Harrison of the Michigan Carton Co. These men made an outstanding contribution to the Austrian pulp and paper industry and they will be long remembered in Austria for their tireless efforts.

As a result of these studies, many changes were made in the projects. After these recommended changes were made, it was unanimously agreed that the over-all program was an outstanding one from every standpoint. The over-all program originally called for total expenditures amounting to 984 million Austrian schillings, or the equivalent of $46 million.

Modernization Pays

Profits from stepped-up production, better sheet quality and a wider range of paper products have paid for machine modernization programs in some of America's greatest mills.

Modernization may mean the replacement of an obsolete drive, the addition of a new Wet End, a new Press Part, a new Size Press. It may call for the replacement of inefficient dryers. It might be the complete rebuilding of the machine itself.

As a typical example, Union Bag and Paper Corporation, Savannah, Ga., recently replaced all the low pressure 65 pound dryers (71 paper and 18 felt) in their No. 4 machine with new high-pressure 125 pound dryers. In a unique operation, their engineers, maintenance and operating crews made the change while the machine continued to turn out paper, by isolating each of the four dryer sections in turn, then by-passing that section in which the new dryers were being installed. The machine was stopped only long enough to disconnect the dryer section to be changed. About a week prior to each shut-down the bottom dryer felt on the particular section was removed and necessary work begun to permit by-passing the sheet.

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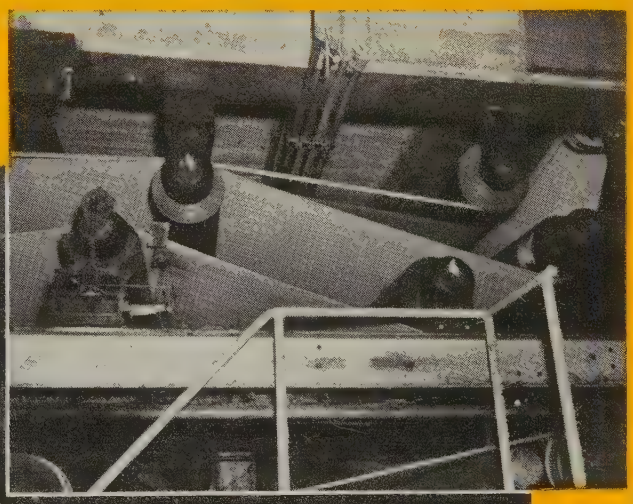

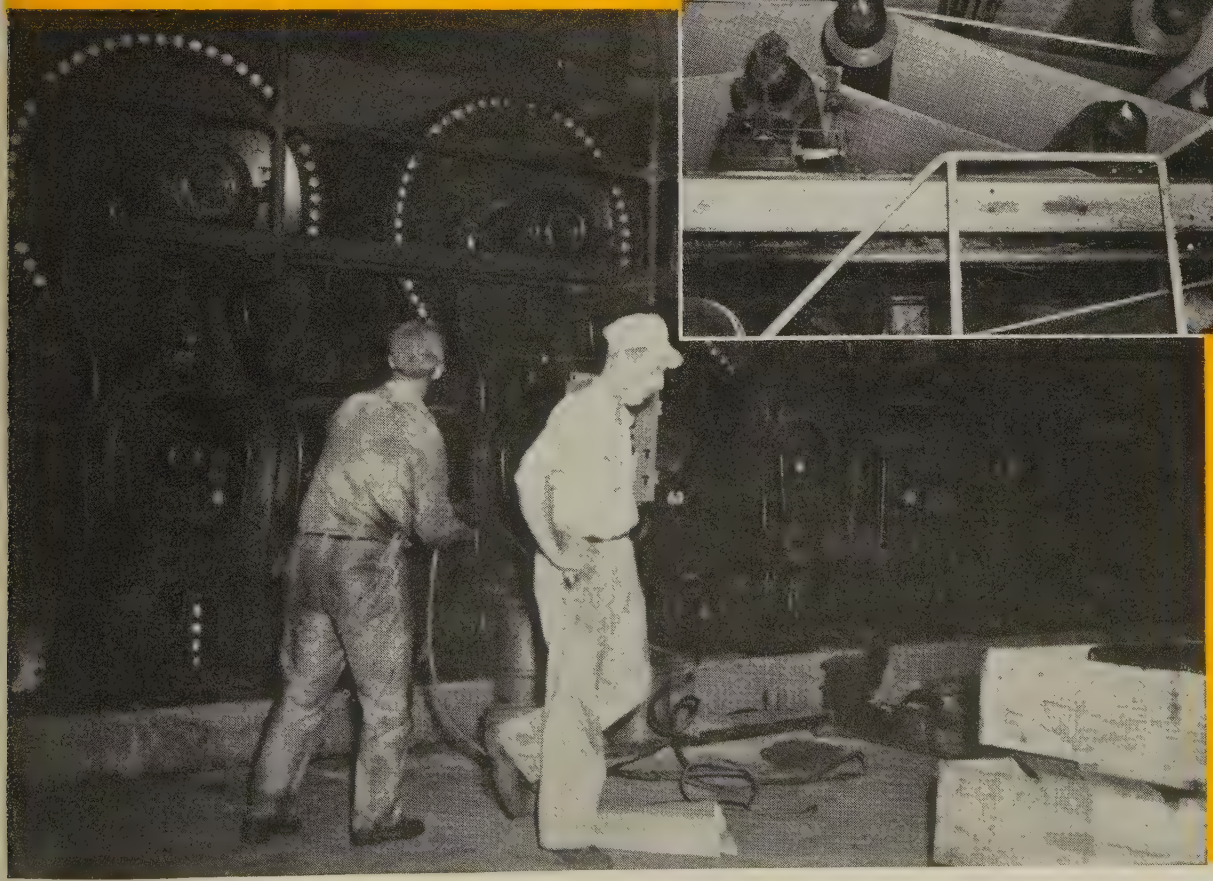

High-pressure dryers in place ready for installation of felts.

Basement run of paper when by-passing the isolated section and while new dryers being installed.

However, after careful screening the direct ECA dollar financing was reduced from an original estimate of $24,500,000 to $6,200,000. All possible sources of European equipment were exploited to the utmost and, of course, this equipment is being paid for in European currencies—not in dollars. Since that time, as a result of rather severe inflationary conditions in Austria, the total costs for the program have risen to 1388 million schillings, or the equivalent of more than $65 million. However, the direct dollar aid has not been increased at all.

Now just what are the objectives of this huge program?

1. It provides for long overdue modernization and rationalization of all major sectors of the Austrian pulp and paper industry.

2. It will result in increased production of pulp, paper, and paperboard. During 1949, when the program was presented, the industry produced 289,000 metric tons of pulp and 224,000 tons of paper. After completion of this program, during 1953 we expect production to be 435,000 metric tons of pulp and 350,000 tons of paper. In addition, production of board will be increased from 52,000 metric tons to 124,000 tons.

3. The program will contribute greatly toward supplying critical needs of the rest of Western Europe.

4. It will result in better quality products at lower costs.

5. It will provide for greatly increased foreign currency earnings for Austria. Foreign currency earnings from exports of pulp and paper in 1949 amounted to the equivalent of 20 million dollars. It was conservatively estimated then that these earnings could be increased to at least 40 million dollars.

Then what progress has been made in this program?

After visiting many of the Austrian mills last November, I am convinced that great progress is being made. There is no doubt that a short space of 3 years' time will have seen a major portion of the Austrian pulp and paper industry rise from a position of having the most obsolete and antiquated equipment in Europe to a position of being one of the most modern pulp and paper industries in the world.

This will be a record to be proud of. We in MSA are all proud to have taken such an important part in promoting and financing the program. It is doubtful that any other sector of the investment program will contribute so much to the Austrian economy in relationship to the total money spent.

Foreign currency earnings have already far surpassed the original estimates. They rose from the equivalent of $20 million in 1949 to $34 million in 1950 and to $70 million in 1951. Estimates have been revised and it now appears as though pulp and paper exports may earn as much as the equivalent of $80 million during 1953. This development alone justifies the costs for the investment program.

In spite of the great advantages of this program in Austria, we have received criticism for supporting it. Some people have expressed the view that shipment of equipment to European countries which *could* be overrun by Russia is unwise. I'm afraid that if the United States had accepted that view we would never have sponsored the Marshall Plan, the NATO, the Truman Doctrine, nor the Mutual Security Program. It has been known ever since 1945 that Russia was capable of overrunning Western Europe.

Our military, political, and economic objectives in Western Europe are directed toward stopping any further Russian advance. As a result of the Marshall Plan, communism has been rolled back in every Western European country so that in most of the governments there is no longer any communist party representation. Even in the Soviet-controlled Eastern Zone of Austria the communist vote was only 5% in the last election. The Austrian people have had good reason to be stubborn opponents of communism since they are able to observe it at first hand in their own backyard. Unlike Germany, which is split in two, the Austrian economy is treated as a whole and the people are able to travel from one zone to another with complete freedom.

If we were to cut off our assistance to the Austrian economy merely because Austria *might* be overrun by the Russian armies, we would take the surest way of presenting Austria to Russia on a silver platter. We have learned from experience that when a power vacuum is left, the Russians or their agents rapidly fill it.

We feel strongly that any delay in this program would not only be detrimental to the economy of Austria, but would be detrimental to the combined defense effort of Western Europe as a whole. We have complete confidence that the entire program will be completed in time to fulfill the 1953 production estimates.

But Austria alone cannot fulfill all of the increased European demands.

Portugal is another country which has pulpwood available to support expansion of production facilities. As a result, a project is now under way for construction of a completely integrated kraft pulp and paper mill for production of 32,000 metric tons of kraft products per year.

In Germany, one project has been proposed for construction of a large kraft pulp mill. It will involve a completely integrated operation with both kraft and semichemical pulp mills operating, combined with a paper mill and board mill, multiwall bag plant, and container plant. This mill expects to use a high percentage of wastewood from sawmill operations for the kraft pulp. Thus all possible sources of softwood are being exploited.

So much for the prospects for increased production based on softwood.

It is quite obvious that even if every available stick of softwood pulpwood in Western Europe were utilized, there would still not be enough to supply the future demand for pulp and paper. Other fibers must be exploited.

Increased use of straw, esparto, hardwoods, and waste paper offer part of the answer.

Exploitation of the mixed tropical hardwoods in the overseas territories offers additional possibilities.

The Marshall Plan countries have explored all of these possibilities and aggressive action is being taken on the most promising prospect.

The use of straw has already reached a high state of development in some of the European countries. Many additional mills have been built during the past two years, and many more are now under construction. I have visited many of these straw pulp mills and have

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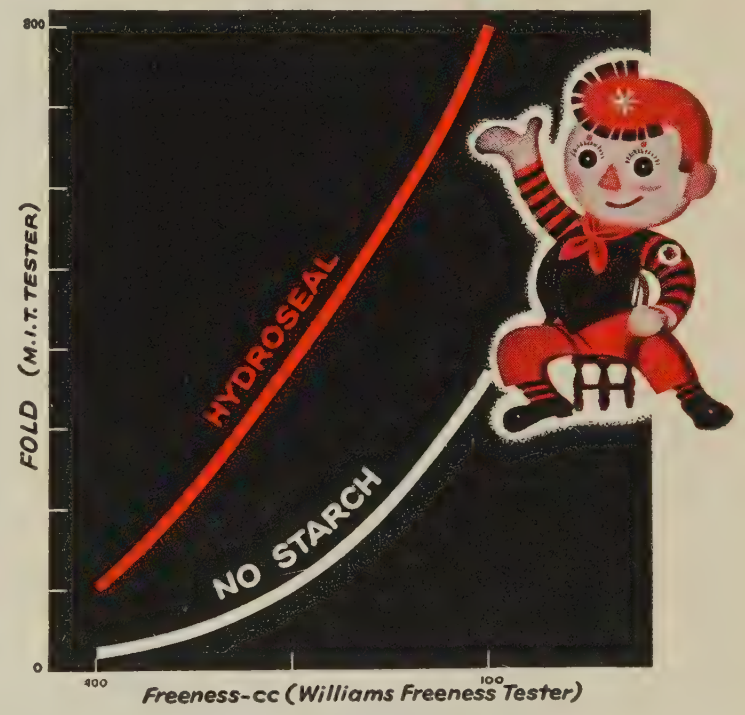

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heard enthusiastic reports of results obtained by blending straw pulp and wood pulp. This is a significant development. We are encouraging it in every way.

Another interesting development in the use of annual crops is the trend toward integrated operations in the production of paper from esparto in North Africa. We have also supported that development.

In the use of hardwoods important developments are rapidly taking place.

Almost all of the mechanical pulp in Italy is made from poplar and practically all of their newsprint is made with this poplar groundwood. For the past 20 years, Italy has been cultivating poplar as a crop.

One of our important projects in this field involved expenditure of $1,650,000 for the first modern high-speed newsprint machine in Italy. Incidentally, the major portion of that machine was made right here by Sandy Hill. The company, Cartiere Burgo, is using poplar entirely as a source of fibrous raw material for this machine. Thus, the European newsprint production has been increased by 30,000 tons per year without involving any new drain on the softwood supply.

Many other countries are going forward with large-scale cultivation of poplar for future pulpwood supplies.

Beech is being used for production of high quality dissolving pulp in Italy, Austria, and Germany. Other developments are under way to expand the use of this hardwood for both dissolving pulp and semichemical pulp.

Another hardwood which has great promise for the future is eucalyptus. It can be cultivated very easily in Southern Europe and North Africa and it is already in use in Portugal, Spain, and Morocco. Many long term projects are under study for cultivation and use of this excellent short-fibered wood.

The mixed tropical hardwoods are also being studied extensively

The use of wastepaper has expanded in Europe beyond all expectations. Its greatly increased use during 1951 was one of the principal reasons for the high level of paper and board production. In the Netherlands, for example, 42% of all paper consumed was collected as wastepaper. In the United States we rarely collect more than 30%.

Now you might ask what effect all of these European developments will have on the United States pulp and paper industry. The high tariff boys are already predicting a flood of European paper to the United States market unless tariffs are increased.

For the life of me I cannot see how this program can hurt the United States industry. In view of the great need for increased consumption of paper in Europe, combined with their high costs of raw materials, I do not foresee any appreciable increase in volume of exports of pulp and paper from Europe to the United States.

In fact, the trend seems to be the other way. At the present time, the annual consumption of paper in Europe varies from country to country, but the average for Western Europe during 1951 was 76 pounds per capita. This is in contrast to almost 400 pounds per capita in the United States. Furthermore, total consumption of paper and board in the United States almost doubled between 1938 and 1951 whereas the per capita consumption in Europe is still below prewar levels of 80 pounds per capita.

As industrial activity continues to increase, and as the Europeans realize the tremendous advantages in using paper for many purposes, the consumption must certainly rise. For each 10 pounds of increased consumption for the 276,000,000 people in Western Europe, 1,350,000 tons of additional paper will be required. I know that you will agree with me that consumption is certain to increase at a rapid rate.

Then, just where is the paper, the paperboard, or the raw material to produce it to come from? I feel certain that more and more of it will come from the Western Hemisphere. Already, in 1951, exports of pulp, paper, and paperboard from the United States surpassed all prewar records by a large margin. This trend will continue if we do not hamstring trade with higher protective tariffs and trade restrictions.

Let us not attempt to keep out the trickle of European paper which might find its way to the United States during the next few years. Instead, let us make every effort to expand this trade to the utmost in both directions. Let us promote the expansion of both production and consumption of paper the world over.

If we do this, and I feel confident that we shall, then we can be assured that the pulp and paper industry will fulfill its rightful role in building the strength of the free world.

PRESENTED at a reception for Ferdinand Wultsch, Arland Pulp & Pulp Mills, Graz, Austria, sponsored by the Sandy Hill Iron & Brass Works, Hudson Falls, N. Y., held at the Queensburg Hotel, Glens Falls, N. Y., April 29, 1952.

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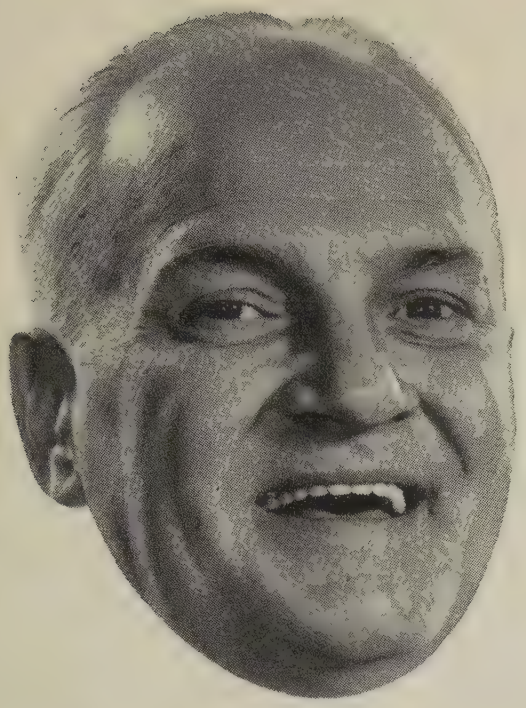

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Because Reliance Application Engineers have had long and diversified experience in applying complete drive systems to paper mill machinery, the investment made in this new 148" supercalender, winder and 2-drum rewinder is returning the greatest possible dividends in quality and quantity of production.

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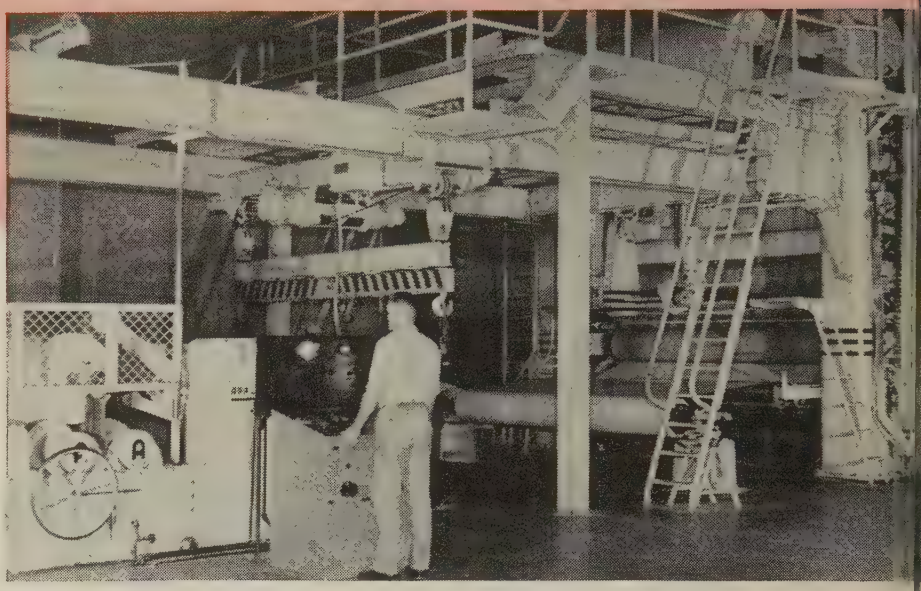
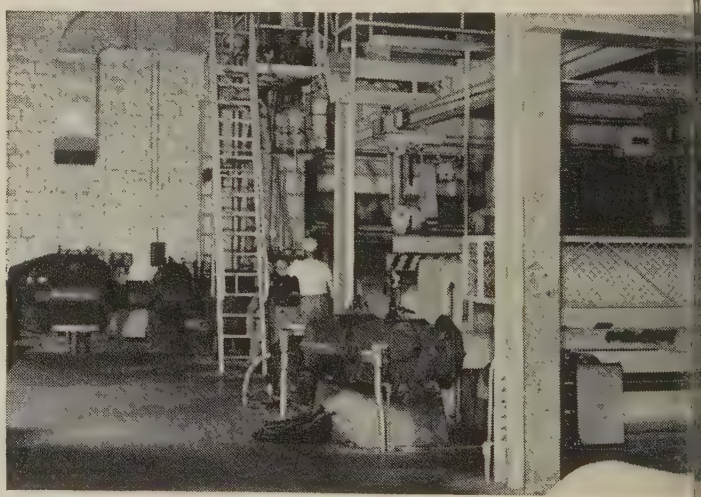


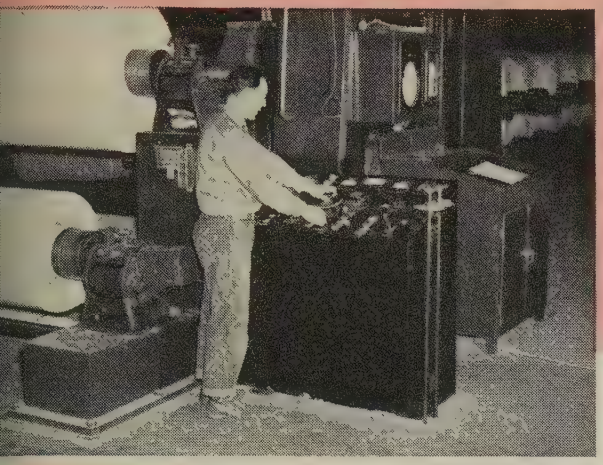
40 FPM. to 2000 FPM. Reliance motor drive operates th supercalender at any speed from a low threading spee of 40 fpm. to a high operating speed of 2000 fpm. I addition to controlling speed of the entire machine, Reliance Electronic Control provides pre-set speed ov the complete range and controlled linear acceleratio and deceleration.

Constant or Tapered Tension Control of Winder—Automatically! Shaft-type winder is equipped with separate Reliance Motor Drive controlled by a Reliance Electronic Regulator which limits thread speed and also gives operator automatic control of either constant or tapered tension on the paper. Whatever degree of hardness is desired can be achieved in the roll.

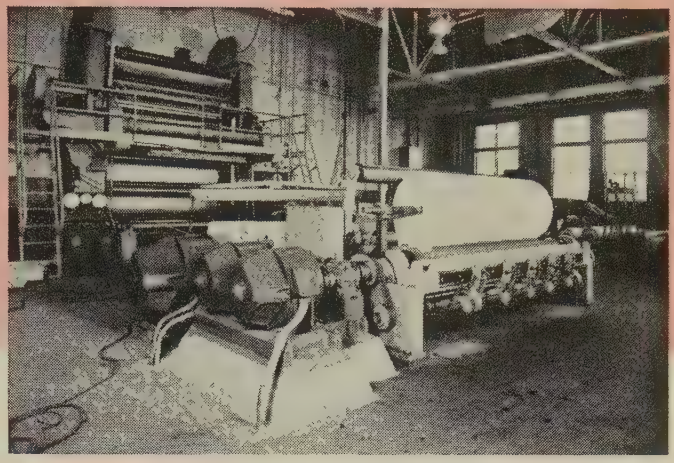


Reliance V★S Drive Controls Tension and Speed of Rewin —Electronically! Two-drum rewinder is operated b Reliance V★S Drive incorporating a Reliance Electron Regulator. In addition to providing automatic control either constant or tapered tension and feed-in speed, t Regulator compensates for increased windage losses higher operating speeds.

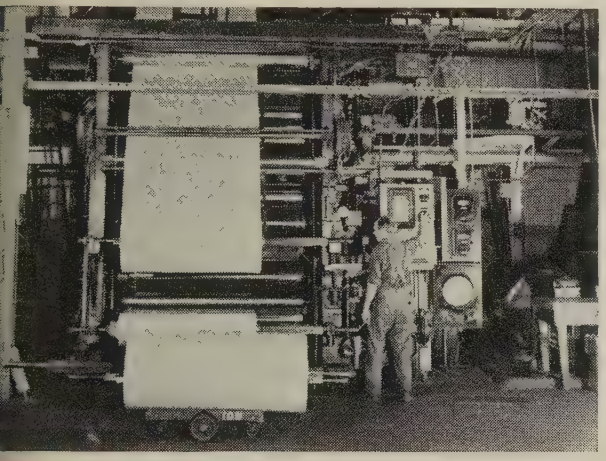
pplications like these, RELIANCE DRIVES are helping paper mills maintain quality and maximum production in supercalendering



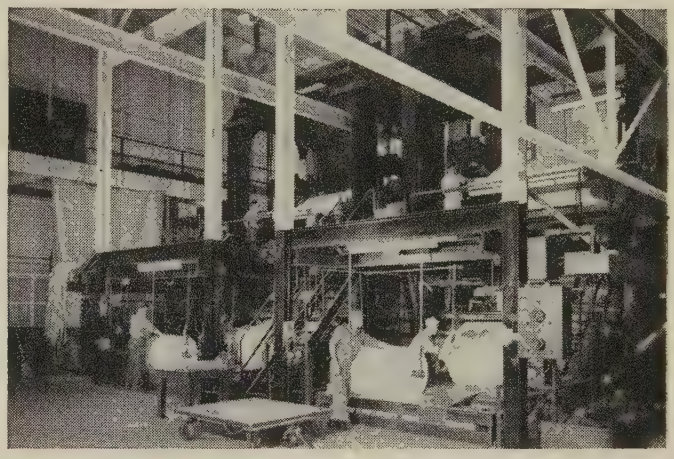
tor Convenience of Reliance Drives is notable in this supercalender application. With centralized con- he operator can easily make adjustments in tension ange pre-set speeds.



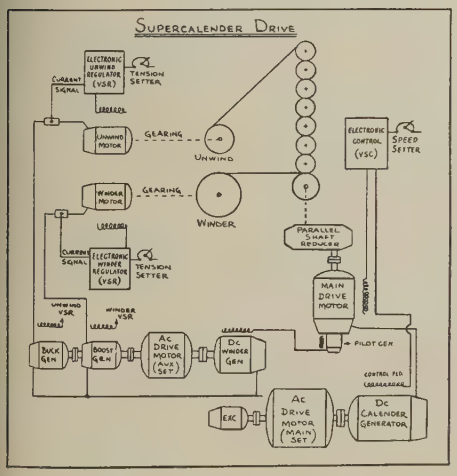
Edge Guide Control saves paper on this unwind. Reliance electronic edge guide control shifts the rewinder roll so that the side trim is kept constant and narrower trim is made possible.



ged Drive Saves Space on this supercalender instal- , driven by a Reliance V★S Drive with electronic ol. The electronic unit provides for timed-rate eration and deceleration, pre-set speeds and im- d speed regulation.



Individual Field Rheostats are used for varying the hardness of the rolls on the 4-drum winder of this supercalender application. With a Reliance motor for each drum, operators can adjust the load of each drum as required.



Typical Reliance-engineered Drive for supercalender with shaft-type unwind and shaft-type winder is illustrated here. Drive consists of all electrical equipment necessary for power and control. In addition to variable voltage control, motor field control is incorporated to provide increased torque for operation below maximum line speed. Electronic units provide timed-rate acceleration and deceleration, pre-set speeds and improved speed regulation in operation of supercalender and tension regulation in operation of unwind and winder.

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Industrial Cellulose Research

WENDELL W. MOYER

CELLULOSE is a uniquely appropriate object to study under the lens of the instrument known as industrial research. Counting the products which depend upon their cellulosic content for the properties that make them useful, such as lumber, plywood, building and insulating boards, carton board, fiber cordage and textiles, along with products derived from purified cellulosic materials, cellulose exceeds in quantity and distribution any other substance used by man. Cellulose is the most abundant of natural products because it was developed by nature as the chief structural element for the physical support of all higher plants. It originates as a product of the photosynthesis process of plants and hence the supply is one that "grows" —not an accumulated resource. Cellulose utilization can be traced to the beginning of civilization, and the tremendous scientific advances of the 20th century have merely increased the consumption by diversifying the end uses.

Before concentrating on the object of cellulose and its place in the industrial scene, it is desirable to consider the scope and limitations of industrial research. We are not going to see anything about cellulose that is beyond the resolving power of the instrument at our disposal. The position that cellulose occupies in our affairs has been attained by sound principles of industrial research, and it is certain that no spectacular achievements will be realized in the future that run counter to sound practices.

Natural products that are accessible to many people are always the target for promotions by the unscrupulous and by the well-intentioned but uninformed. Disregarding all dishonest efforts, the causes of failure of projects aimed at the utilization of natural products, such as cellulosic materials, should be reviewed if we are to draw any conclusions on where we are, and where we are going, and why.

Industrial research is generally considered to be the application of natural laws and fundamental knowledge to the production of things that people need and want. What they want has a lot more psychological drive behind it than what they need. People will buy what they want and pay a profit to those who produce for them. In many cases value is measured purely by utility; and in others, factors such as appearance, convenience, and emotional appeals are of equal or greater importance. We are comparing hemp rope with rayon, or kraft paper with cellophane.

WILL PEOPLE BUY IT?

This paper does not purport to be a treatise on applied psychology, but the psychological evaluation is the first step to be taken in any industrial research project aimed at the development of a new product. Is the product something that people desire more than comparable products that are available? Will people buy the product at prices that will likely afford a profit? These questions appear so elementary that often they are passed over completely at a heavy penalty later of disillusionment and expense. Correct intuitive evaluation of the psychological factors is covered by the term "common sense." Large research organizations do not rely on intuition or common sense; they make thorough market surveys.

The lack of a psychological evaluation, made objectively, is a minor error compared to the damage that is done by a nonobjective evaluation, influenced by the personal interests of individuals and groups. The insidiousness of a biased evaluation is that the compulsion toward it is usually in the subconscious mind. In the desire to utilize a certain raw material, subjective factors creep in and wishful thinking takes the place of sound logic. This astigmatism of the mental vision is responsible for a host of mishaps. It causes one to overestimate the desirable properties of a new product and underestimate the deficiencies, while at the same time miraculously reversing the process when examining existing products that will be competitive. It causes one to inaugurate projects that run counter to a clearly evident technological trend. It causes one to interpret local conditions on a national scale, and to assume that an abnormal period of demand is a continuing economic condition. It causes one to ignore or underestimate the importance of many nontechnical problems upon which a successful industrial development depends. It causes one to overlook the consequences of success, that the pioneer of a useful new product invites competition which might prevail by virtue of cheaper raw materials or an improved process.

To a scientist, whether pursuing fundamental discoveries in a university laboratory or working for an industrial organization as a livelihood, there is a great spiritual satisfaction in creative effort. Below this, research is a competitive struggle. The pure scientists compete for honor and renown, the industrial scientists compete with nature and other groups to obtain for the companies that employ them a greater share of the money the ultimate consumer has to spend. In the last analysis, industrial research is a new type of competitive enterprise that has been employed by industry to ensure profits. Fortunately, the competition with nature results in new wealth which gives the consumer more money to buy the end products of research.

Industrial research is the most powerful instrument that has been devised by the human race for the creation of wealth. Its successful use depends upon an objective evaluation of the problems which it is pressed to undertake and a most respectful attention to the competitive scientific and economic elements that are in force in our free enterprise system of economy. Cellulose materials have no natural exemption to the rules

WENDELL W. MOYER, Director of Research, Crown Zellerbach Corp, Camas, Wash.

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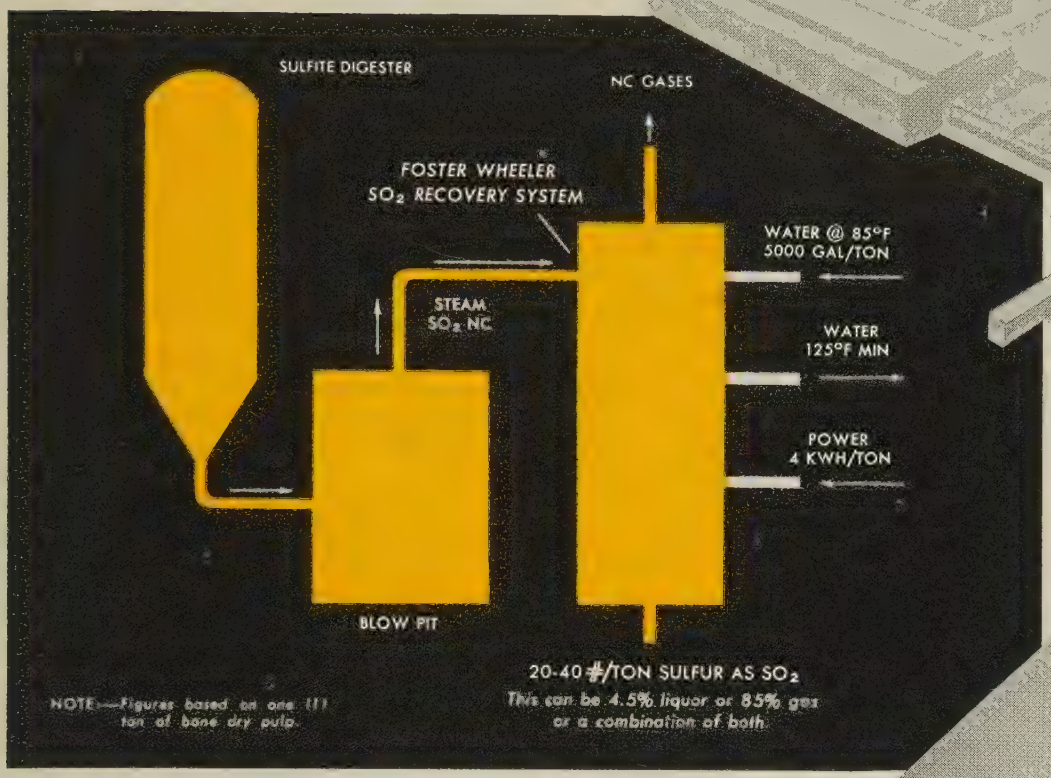
sulfur and heat recovery from sulphite digester blow steam



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Gymnosperm wood fibers. Douglas-fir. Magnified 100×

of good industrial research because they grow on every farm and forest land. In fact as may be surmised, the widespread abundance of cellulose and its mainfold uses make it a particularly susceptible object of misdirected research efforts.

A definition of cellulose in the industrial field is in order here even though it may serve only as an excuse to misuse the word. Cellulose is used generically to characterize the various products derived from vege table matter which contain predominantly the ideal set by chemists, alpha-cellulose. Alpha-cellulose is a polysaccharide built up of straight chains of glucopyranose rings joined from the first to the fourth carbon atom by beta-linkages. Furthermore the degree of polymerization must be such that the molecules are insoluble in dilute alkalies and acids, and have an organization that gives a typical x-ray diagram. The degree of polymerization of alpha-cellulose is not a fixed quality but, like starch, varies from plant species to species. The cellulose of industry contains the alpha species in various degrees of purity, the tolerance to impurities depending upon the end uses.

Alpha-cellulose does not occur in pure form in nature. Vegetable matter may contain from a small amount to almost 98% in the best cotton lint fibers. The majority of plant materials contain from 30 to 50%. Associated with natural cellulose are a group of polysaccharides known as hemicelluloses which have many properties similar to alpha-cellulose but are of much lower molecular weight and contain sugars other than glucose in their structure, as well as uronic acid residues. Another class of carbohydrates commonly associated with cellulose comprise the pentosans, and in particular, xylan. The chief noncarbohydrate companion of cellulose is lignin. The relationship between lignin and cellulose is so close that many of the processes used for purifying cellulosic materials may be properly called delignification processes. Among the minor impurities are gums, pectins, fats, waxes, sugars, resins, and lignans.

ITS UNUSUAL PROPERTIES

The unusual properties that distinguish cellulose from other carbohydrates and make it so useful can be traced to the linearity and high degree of polymerization of the molecules. The beta linkage minimizes curling and spiraling and permits the molecules to line up with a high degree of orientation to form, in a high percentage of cases a fibrous structure. The organization of cellulose into a fibrous shape is the unique characteristic that makes cellulose so widely useful in industry. Cotton and linen textiles owe their existence to the natural fiber occurring in the seed hairs of cotton and the bast fibers of flax. Paper is made by a mat-forming process on isolated fibers from wood and other sources. Many of the natural cellulosic fibers of industry consist of unseparated fiber bundles, or filaments, rather than individual fibers that have been reformed. Among these are the bast, fibrovascular, and leaf fibers of plants such as jute, hemp, and sisal which are used for rope, cordage, and bagging.

ECONOMICS VERSUS CHEMISTRY

An organic chemist might evaluate cellulose as a chemical raw material on the basis of the desired degree of polymerization and freedom from impurities, and hence draw the conclusion that economics would dictate the source of supply. To a large extent this is true, but again the kind of fiber and the way it is prepared play very important roles. Every plant species produces a different type of fiber. The variations are in length, thickness, smoothness, shape, and organization of the cellulose molecules. Since chemical reactions with cellulose involve a heterogeneous phase, the speed of reaction and the control will depend upon the accessibility of the cellulose molecules to the reactants. A thick, highly oriented or crystalline fiber cannot be attacked as readily as a thin fiber having less orientation and more amorphous areas. The presence of fiber bundles not broken down during prior processing or formed by matting are particularly deleterious. The

Angiosperm wood fibers. Cottonwood. Magnified 100×

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importance of the physical condition of the cellulose fibers is illustrated particularly by the nitration reaction which is very rapid. Fiber bundles are undernitrated and the individual fibers are overnitrated.

Not to digress from the general nature of this discussion, the problems of industrial research on cellulose can be divided into five broad divisions:

1. Supply problems.
2. Purification problems.
3. Application problems.
4. Chemical problems.
5. Fundamental problems.

In commenting briefly on each of these types of problems, it is well to keep in mind the competitive nature of industrial research which was mentioned above. The many sources of cellulose compete with each other for their place in the economic sun, and cellulose, irrespective of source, must compete with other raw materials for the consumers' dollars.

Supply problems concern all phases of obtaining plant raw materials for cellulose in its existing uses and for new uses. Some of these problems do not involve chemical research and seem aloof from the activities of a laboratory or pilot plant, but they are problems to be considered to ensure industrial success later.

To explain the factors behind the status of current cellulosic sources such as wood, cotton, hemp, straw, for example, it is perhaps easier to start with an analysis of a hypothetical problem: Can plant species "Z" be utilized to produce a grade of commercial cellulose? In a preliminary survey a number of questions must be raised and answered with a fair degree of accuracy. Does species "Z" have any other economic values such as oil-bearing seeds, tannin, or alkaloids that can be realized? What is the cellulose content? Where is it located? What are the associated noncellulose materials? Are the impurities of such nature that they would interfere with physical and chemical purification processes? What is the yield per acre per annum? What is the value of the land to be used for growing "Z?" What is the probability that another crop can be grown more profitably? How can the crop be harvested—any special equipment required? Is harvesting a seasonal or year-round proposition? What is the cost of collecting and delivering to a processing plant? Are there any unusual storage problems? This is not a comprehensive list, but the wrong answer to any of the above questions can spell failure even though all the other factors are favorable.

AGRICULTURAL RESIDUES

The list is not so long when the raw material under consideration is the by-product of crops grown for other values, such as corn stocks, sugar cane bagasse, wheat straw, and many others. However, lessening the number of factors does not greatly alter the severity of the problem because the ones that remain are extremely critical. Here is the problem of what is termed "agricultural residues" as sources of cellulose. These residues comprise a stupendous potential source of cellulose, almost untapped, because of economic barriers that can't be breached under present conditions. The cotton plant produces far more cellulose in the roots, stalks, and leaves than in the form of seed hairs, yet only the latter has commercial value.

Also in active competition with new sources of supply, are the improvements in the availability and cost of cellulose from established sources. Gymnosperm wood is an excellent example. Although wood contains only from 40 to 50% cellulose, it provides the most favorable answers to many of the questions posed for other plants and agricultural residues. As a result, in the early days of pulping wood, logging practices were wasteful and no consideration was given to growing another crop. The unprecedented demand for wood pulp, primarily because it was cheap, depleted forest reserves at an alarming rate and focused attention to the advantages of wood that had previously been taken for granted.

At the present time in the Pacific Northwest, and increasingly so in the South, trees are farmed as an agricultural crop, the farmers being professional foresters. Yields are increased by scientific logging, thinning, replanting, and seeding. The crop is protected against insect pests by spraying, and from fire hazard by watchers, well-built fire-roads, and clean-up of logging debris. Experiments in hybridization are being made to increase growth rate and improve fiber quality. The pulp mills are being geared to areas of land which will supply sufficient logs to keep the mills running at capacity forever.

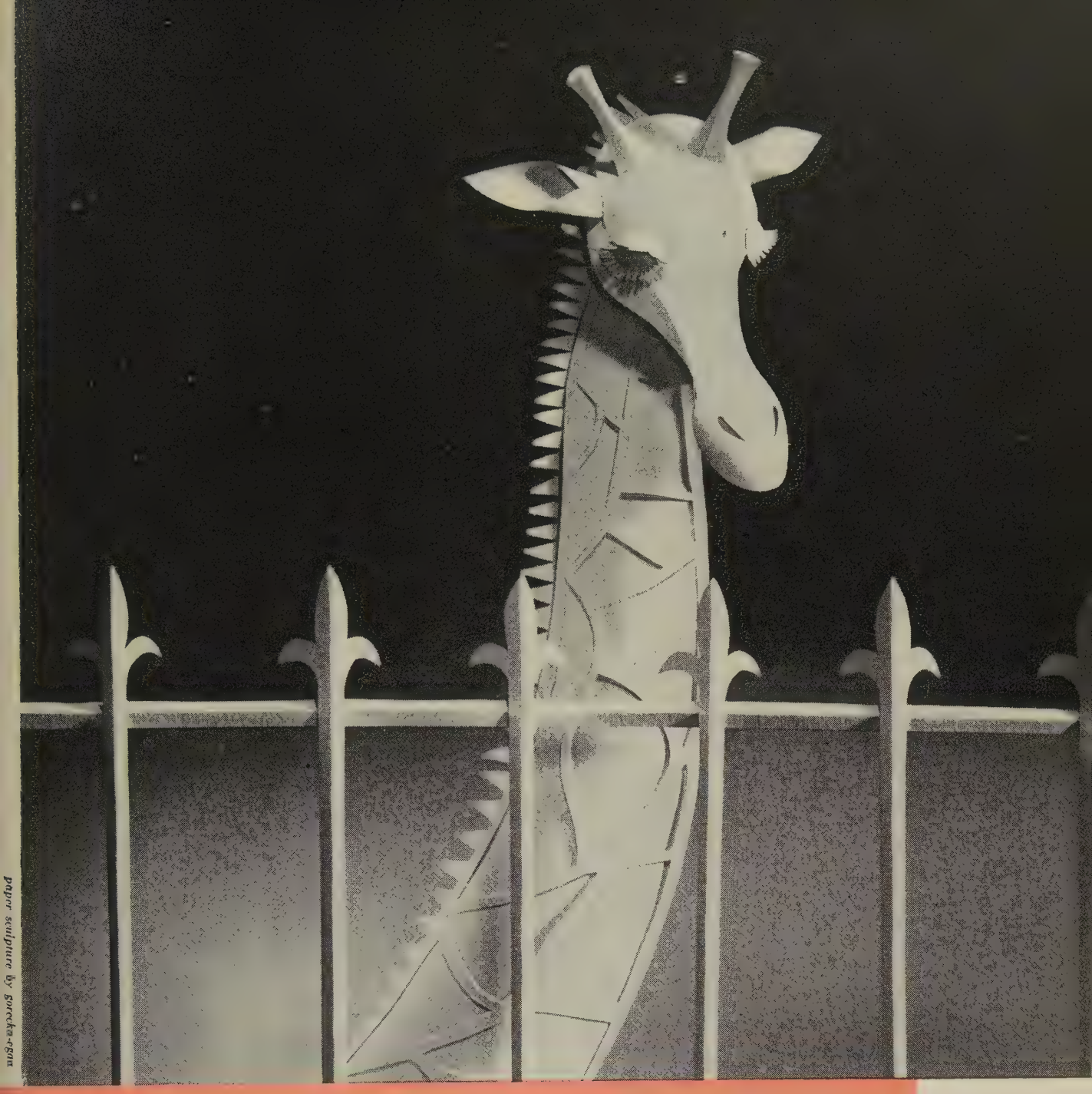
ECONOMICS KEY TO SUPPLY

If the supply problems connected with the evaluation of a source of cellulose can be solved economically, there is great reason to be encouraged about the eventual success of the project. The next step in the procedure, the isolation of the cellulose in a form suitable for some industrial application, is on a more objective plane because information can be developed by experimental methods. All the problems in this area are designated purification problems.

The first one is the removal of dirt and extraneous substances from the plant material. Only for the coarsest uses can an appreciable amount of inorganic or dark-colored organic dirt be tolerated in cellulose fibers. For example, the carbon particles from a fire-charred log can ruin a large batch of papermaking pulp. The best place to remove dirt is at the beginning, not after the plant has been reduced to fibers.

The next step is to determine, with due regard to the contemplated end use, how much of the undesired portions of the plant material can or should be removed by physical means before using any pulping or chemical process. By way of illustration, bagasse is composed of about 50% of pith that should be removed by a physical process before attempting to pulp the fibrous stalks; the cost of pulping chemical to solubilize the pith exceeds that of the preliminary mechanical processing.

The required type and degree of purification depend entirely upon the field of utilization of the cellulose, and it has been assumed that this has been understood in the discussion of supply problems. The application field may be divided into three areas: the first includes uses which require only the elimination of the nonfibrous portions of the plant to leave the fibrous part in which the cellulose remains bound with the hemicelluloses, pentosans, and lignins, for use in such products as wall and insulating boards. The second comprises



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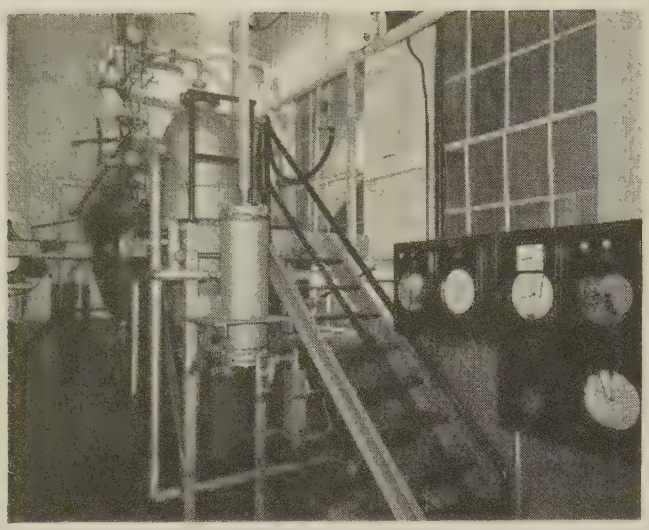

Small digesters for experimental pulping of wood and fibrous materials

the separation of cellulose fiber filaments as, say, in the preparation of ramie fiber; and the third comprises the reduction of cellulose to individual fibers as in the pulping of wood. Superimposed on all three classes may be bleaching problems.

The reduction of the plant raw material to individual fibers is commonly called pulping. The selection of a suitable pulping process again brings in economic factors. The geographical location of the pulping mill and its proximity to chemical supplies and adequate water, as well as disposal of mill effluents, must be carefully analyzed. As indicated under supply, the nature of the noncellulosic material is also a controlling factor. It is safe to say that any plant material can be pulped by the kraft process but the properties of the pulp, the location, cost, and many other considerations may count against kraft pulping. The sulphite process also has limitations; some woods cannot be pulped by the sulphite process because of high resin content or the presence of extractive chemicals that react with the lignin more readily than does the sulphurous acid. The development of a suitable pulping process with the experience available at the present time becomes chiefly a matter of industrious experimentation.

The bleaching of cellulose material to lighten the color and remove residual impurities involves the use of chlorine, hypochlorites, chlorine dioxide, hydrogen peroxides, alkalies, and combinations of these. The ancient method of bleaching in sunlight is hardly applicable in modern industry. The problem of bleaching a new cellulose material is, again, chiefly one of experimentation with various known processes.

The degree of purity of cellulose fibers ties in closely with the third division: application problems. Then end use of the cellulose depends upon the quantity and nature of residual impurities in the fibers.

The paper industry provides an example of one that requires an impure fiber. A pure alpha-cellulose fiber would yield a weak sheet that would have limited utility. A certain small percentage of hemicelluloses and pentosans is necessary to obtain strength due to fiber-to-fiber bonding. On the other hand, too high a content of hemicelluloses produces a glassine type of sheet of limited application.

The evaluation of a cellulose fiber or pulp for one of the established applications such as textiles, paper, or chemical conversion is a highly specialized undertaking that should not be attempted by those who have no more than an academic knowledge of the science and art of the field. Lack of appreciation of this fact has been and will continue to be the cause of wasted money and disappointment.

Each of the thousand-and-one different grades of paper now manufactured have rather specific fiber requirements which must be recognized in order to obtain the desired properties such as tensile strength, burst, tear, formation, fold, stiffness, absorbency, opacity, transparency, density, and smoothness. There is a tremendous amount of know-how in the choice of a suitable fiber furnish for a particular grade. The type of pulping process required, the length and shape of the fibers, the crystallinity of the fiber, the degree of hydration, and cutting by beating and jordaning, to mention only a few, are all significant. Some grades of paper can be made from any fiber furnish, but whether or not said paper will compete with an existing commercial grade is a matter for expert opinion. It is ridiculous to attempt to make newsprint, for example, from a fiber that produces a rattly, transparent sheet that permits ink to show through. The cellulose textile industry imposes likewise a series of limitations on the properties of the fibers it can use to advantage.

For the production of regenerated cellulose products, the alpha-cellulose content must be higher, say above 90%, and impurities, particularly the pentosan content, much lower than for the best papermaking pulp. A natural cellulose product of unusually high pentosan content would not likely be a suitable raw material to be pulped for viscose or cellophane. For the production of cellulose derivatives, in general, it could be said that the purification process should be extended as far as possible to yield alpha-cellulose.

The chemical problems involved in the utilization of cellulose comprise all those concerned with the preparation of chemical derivatives such as the intermediate xanthates in the viscose process, ester, ethers, and acetals, swelling and mercerization, hydrolysis, oxidation, in short, all the operations in which cellulose is treated as an organic compound or as a polysaccharide. These specialized problems will not be discussed here because this field is essentially that of industrial organic chemical research. If one can produce alpha-cellulose of the proper degree of polymerization and in accessible physical form, it can be used for chemical purposes.

The last division comprises what should be called fundamental problems. Fundamental research which seeks new laws and principles is an integral part of a sound industrial research program, although managements frequently prefer to designate all work done in an industrial laboratory as applied because it sounds more practical. Actually, the record shows that the big things originate in research that is indistinguishable in procedure at its beginnings from investigations in any university laboratory.

MANY PROBLEMS AWAIT SOLUTION

An impressive list of fundamental cellulose problems under investigation or waiting for study could be

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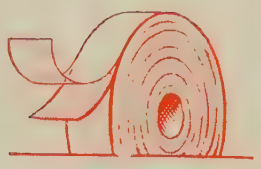

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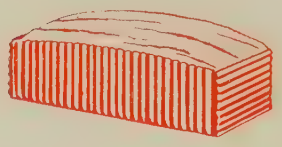

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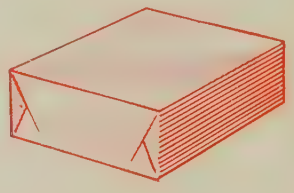
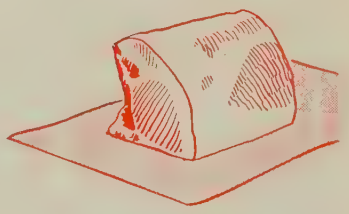


For frozen-food packages and locker wrap, "Quilon" eliminates fiber pull when frozen-food packages are separated and when frozen food is removed from wrap.



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compiled. Among these the following should be mentioned:

1. Studies on the nature of the binding forces between cellulose and the associated carbohydrates in natural materials. Present pulping processes are so harsh that production of fibers is attended by loss of valuable alpha-cellulose as well as loss of desirable strength properties.

2. Further studies on the fine structure of cellulose. Not all of the behavior of cellulose fits well with the concept of linear chains differing only in degree of polymerization.

3. Investigation of the hydrolytic breakdown of cellulose in steps to the ultimate sugar glucose.

4. Physical chemical studies of the modification of fibers by surface treatments, including fiber-to-fiber bonding and absorption of chemicals on surface.

5. Investigation of the influence of fiber crystallinity on the behavior of the fibers.

6. Studies on the distribution of substituents of cellulose derivatives among the 2-, 3-, and 6-positions of the glucopyranose units.

7. A study of means for increasing the elasticity of filaments made from natural and regenerated cellulose.

In conclusion, it is proper to indulge in the interesting but inexact science of prophecy in an attempt to look into the future of cellulose. Scientific method permits the extrapolation of trend curves, and a prophet can insure the accuracy of some of his predictions by making many of them couched in ambiguous terms. Since the following predictions are few in number, the accuracy will depend upon the extrapolation technique.

1. An abrupt shifting upward in the utilization of cellulose will be the out-growth of a new fundamental discovery by research on cellulose. An abrupt downtrend will result from a fundamental discovery made by research on competitive materials.

2. The long-term trend in the utilization of cellulosic fibers, natural and regenerated is upward.

3. The long-term trend in the utilization of cellulose in the form of derivatives is downward and will be reversed only by a heroic discovery that will reduce the production costs.

4. Cellulose nitrate is an exception to the above prediction. Its value in peace, and particularly in war, will increase.

5. Combinations of cellulose with synthetic polymers will find greater and greater fields of application.

6. The hydrolysis of cellulose to glucose and simple oligosaccharides will become a dominant economic factor. The logical solution to the problem of agricultural and forest residues is to convert them to nutritional products to feed an expanding population.

7. Cellulosic by-products will find increased utilization as raw materials for the production of simple aliphatic chemicals through chemical engineering and biological processes.

8. Looking far into the future, we can see that cellulose, the most abundant of all photosynthetic products, will become one of man's most useful raw materials. The supply is replenished by growth while materials stored from past ages are continuously depleted.

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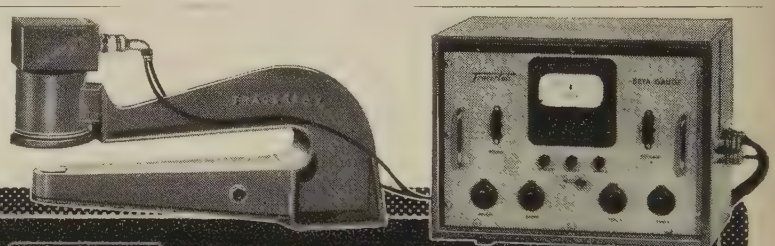
5 WAYS TO SLASH PRODUCTION COSTS



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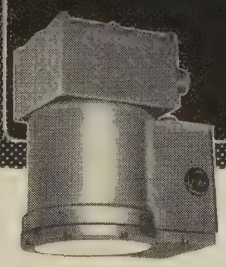

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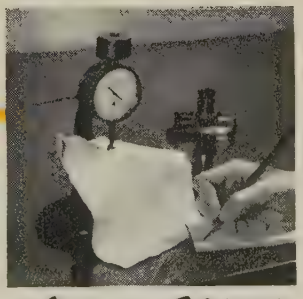

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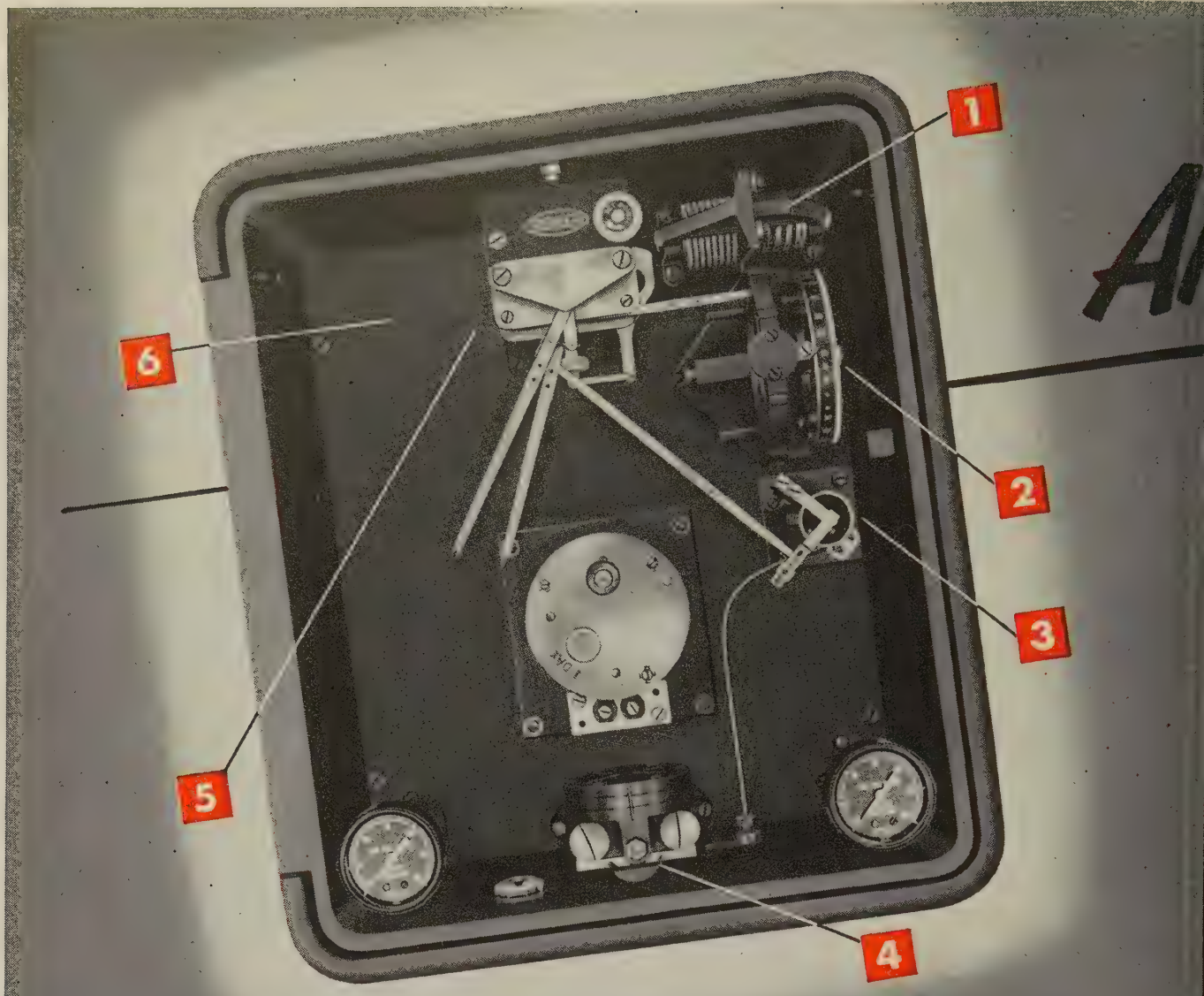

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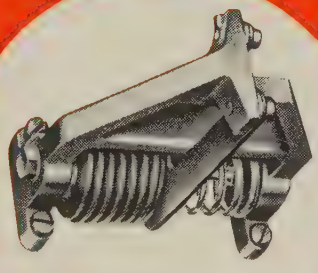

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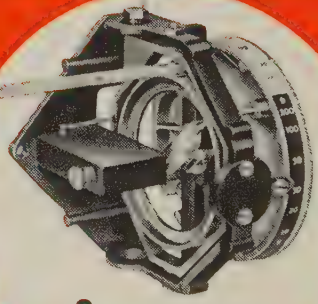

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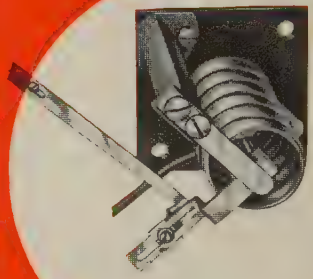

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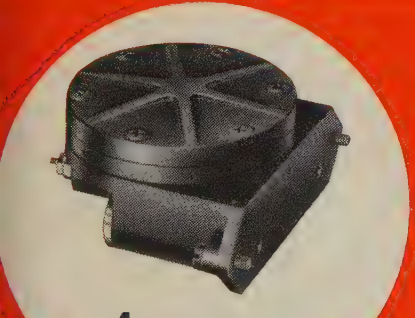

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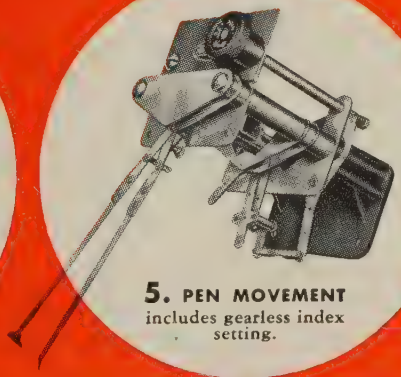

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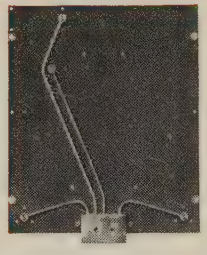

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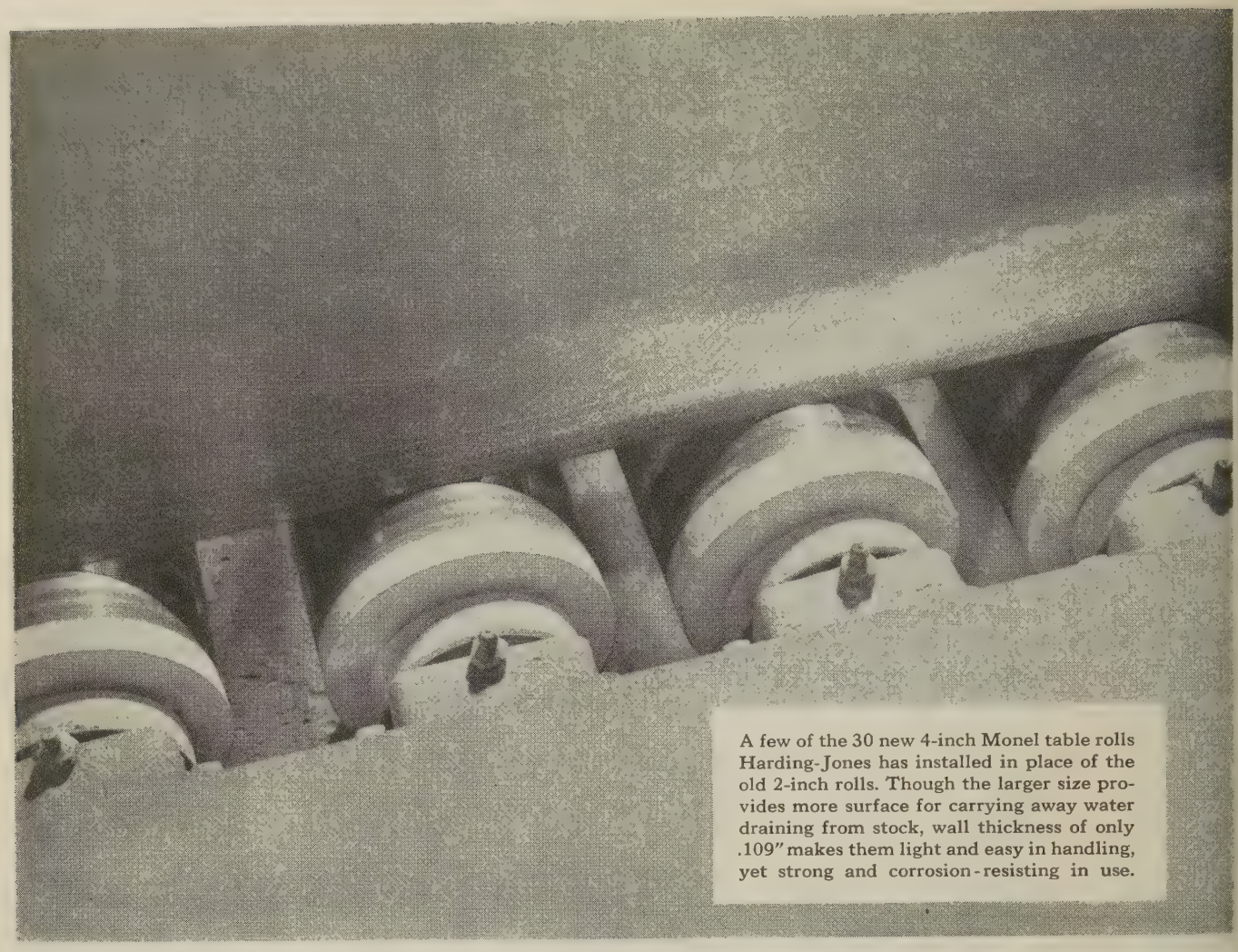

A few of the 30 new 4-inch Monel table rolls Harding-Jones has installed in place of the old 2-inch rolls. Though the larger size provides more surface for carrying away water draining from stock, wall thickness of only .109" makes them light and easy in handling, yet strong and corrosion-resisting in use.

How to "table" your table roll problems

Is corrosion making your table roll surfaces rough? Are they accumulating slime and fibre much too quickly . . . requiring frequent cleaning?

Is roll whip making rolls crooked and useless . . . causing extensive straightening and junking and non-productive down time?

Then you'll be interested in how one company, The Harding-Jones Paper Company of Middletown, Ohio, overcame these costly difficulties. They installed table rolls made of Monel®.

Why Monel? Because Monel's smooth, corrosion-resisting surface discourages slime and fibre accumulation. And Monel's high strength and rigidity, make possible light thin-walled rolls that withstand roll whip and give longer service with less interruption . . . lower operating cost.

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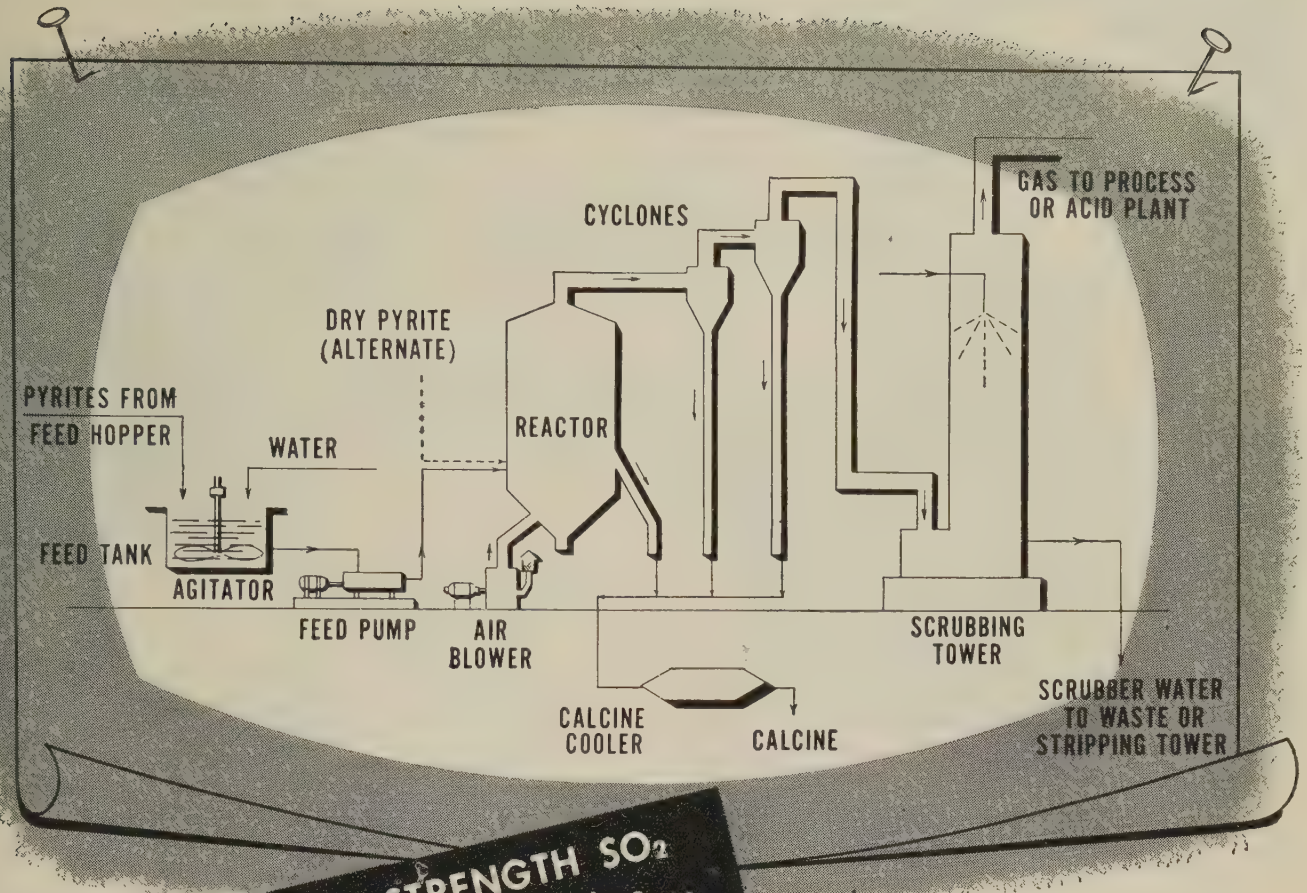

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Dorrco FluoSolids* System gives you 14-15% SO_2 from 48-50% pyrite 12-13% SO_2 from 35% pyrrhotite

Sulphuric acid manufacturers and all users of sulphur dioxide faced with a shortage of elemental sulphur are finding in FluoSolids an economically feasible means of tapping sulphides as an alternate source of SO_2. In sulphite pulp mills alone, eight Dorrco FluoSolids Systems are now being installed.

For detailed information about FluoSolids — a distinct departure from conventional roasters — ask for a copy of Dorrco Bulletin No. 7500. Just write to The Dorr Company, Stamford, Conn., or in Canada, The Dorr Company, 80 Richmond St. West, Toronto 1.

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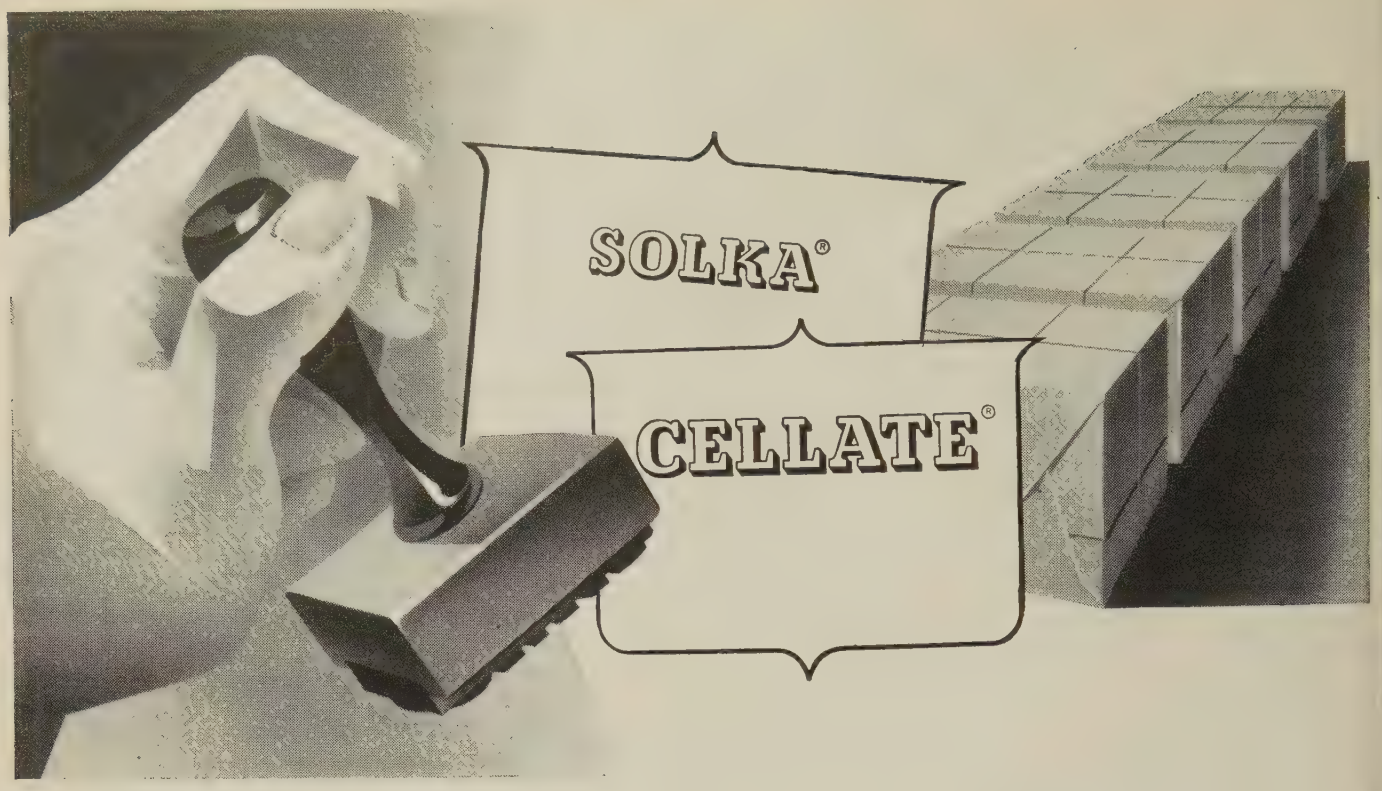

They Set the Standard for Quality

These seals are stamped on all Brown Company Solka and Cellate pulps. They are your assurance of the finest quality pulps manufactured from wood cellulose—pulps that set the standard for quality in the industry. Here's why:

Brown Company pulps are made principally from its own vast timberlands of northern softwood and hardwood. This assures quality control and a dependable source of raw material.

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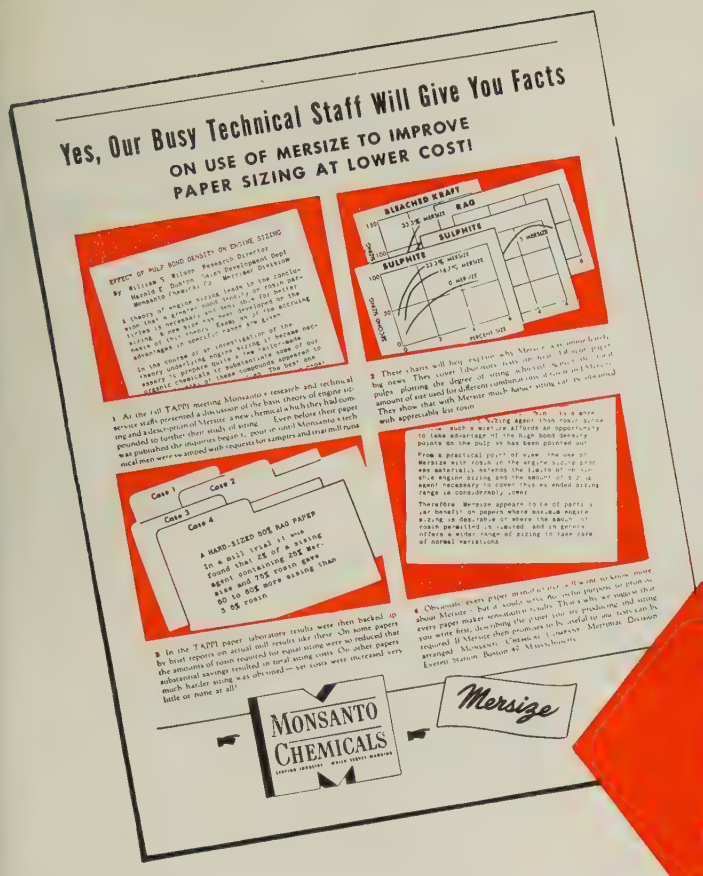

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YOU GET a carload of advantages with every tank car of MERSIZE-RM!

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Praises from Men Who Know pul

FIRM AWARDED BROCHURE PRIZE

LOS ANGELES, Calif.—Advertising experts representing agencies in [illegible] of the country submitted [illegible]es of their creations to a judging here, and a finely printed, informative and technically comprehensive brochure issued by the Sandy Hill Iron and Brass Works of Hudson Falls, N. Y., won first prize as an outstanding piece of advertising literature for a manufacturer.

The First Advertising Agency Group, made up of agencies in major cities of the country, created over a period of more than a year. All judges voted that the unusually complete content, the technical accuracy, and the interesting manner of handling the Sandy Hill book earned it first prize.

The Sandy Hill brochure presents the line of products of the Hudson Falls firm in twelve sections, illustrating, describing and analyzing the functions of related pieces of equipment made by Sandy Hill. For instance, one section treats of the Sandy Hill Selective Drive, and others cover the following subjects: Bertrams Shake, Multi-Cylinder Board Machine, General Purpose Paper Machine, International Grinder, Kamyr Grinder, High Speed Newsprint Machine, Kamyr Pressure Filter, Kamyr Wet Machine, Standard Wet Machines for Paper Making or Pulp Lap Forming, High Speed Tissue Machine.

The book is replete with half-tone illustrations, and with artists' drawings of equipment, with engineers drawings to amplify the uses and typical installations.

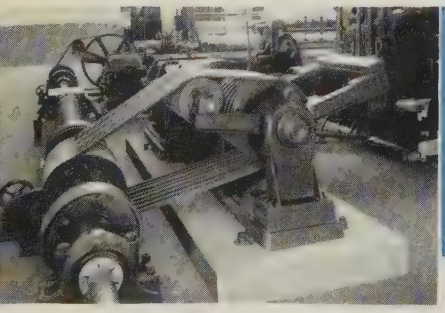
Hevenor Advertising Agency, Inc., of Albany, which handles the Sandy Hill Iron and Brass Works account, prepared the book.

From the very first day that our comprehensive Sandy Hill Brochure came off the press, we have been receiving "rave notices" from every direction. We sincerely appreciate it, and thank those who have taken the time to write or to compliment us in person.

Of course, the primary purpose of this brochure is to delineate the products of Sandy Hill, but we have endeavored at the same time to compile a "ready reference" book of the pulp and paper industry for the assistance of those making decisions and those doing research in the field.

Our eagerness to be helpful does not stop with the production of this catalog. Our large, proficient engineering staff is ready to give you every possible assistance with your particular mill problem. Just give us a call.

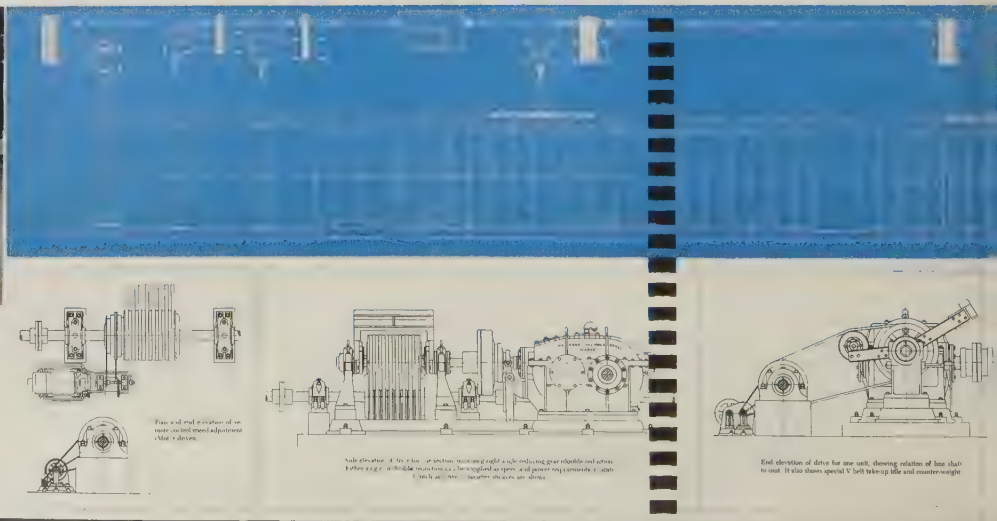
Below are typical examples of page spreads in the Brochure. At left is a triple-page spread describing the Sandy Hill Selective Drive. At right is a double-page spread featuring a general pulp and paper mill scheme with Sandy Hill Equipment and Kamyr Pulp Bleaching.



Efficient Operation; Economical Maintenance

The elements of the Sandy Hill Selective Drive comprise a line shaft on interchangeable roller bearings, adjustable V belt sheaves, companion sheaves, V belts, cut oil coupling, right angle gear reduction unit, pinion shaft with standard and interchangeable roller bearings, gear shaft on interchangeable roller bearings, gear casing and flexible coupling. Compared with any other type drive it has a minimum of moving parts and parts subject to failure. It presents no maintenance problems beyond the ability of a good paper mill millright whose services will be mainly confined to inspection and infrequent adjustment. Installation of the Selective Drive eliminates the need of a basement or steel superstructure for a line shaft. The line shaft is installed on the floor on low piers, not over eighteen inches high.

Sandy Hill SELECTIVE DRIVE



Sandy Hill Catalog in "Best Seller" Cla

JST A FEW of the complimentary messages ceived from leaders in the pulp and paper dustry:

ongratulations to you and yours on your most interest-g and instructive catalog, which I thoroughly enjoyed ading last evening. *Henry D. Schmidt*
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want to express my sincere appreciation for having ceived this excellent catalog, which will be circulated nong the different production executives of our organi-tion. *Erik Fernstrom*
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ou are certainly to be congratulated on the very credit-ble performance of your company. It is always a pleas-e to see the progress Sandy Hill has made since my st acquaintance with it in 1915.
C. R. Seaborne
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'e take pleasure in acknowledging receipt of your very andsome and complete catalog. We have put it where will be referred to many times. Our business relations ith your good company have been very pleasant.
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xcellent presentation of modern paper mill machinery.
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hope copies have been sent to our mill offices.
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wish to thank you very much for sending this wonderful atalog which I have examined and have turned over to ur General Superintendent, who is also pleased with it.
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If you do not have a copy of this complete catalog, write for one today.

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This is indeed a very fine book and we should like to congratulate you on this issue.

John R. Dufford
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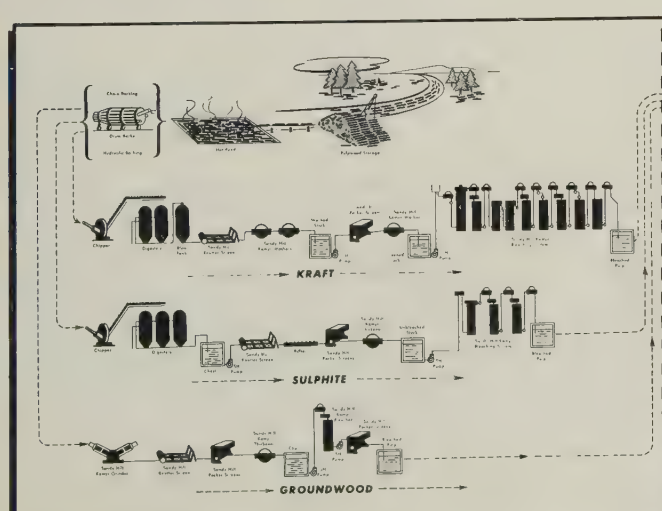
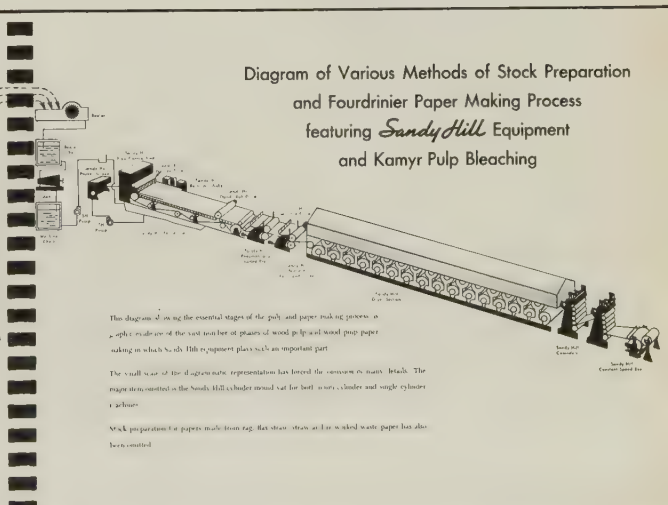


Diagram of Various Methods of Stock Preparation and Fourdrinier Paper Making Process featuring *Sandy Hill* Equipment and Kamyr Pulp Bleaching



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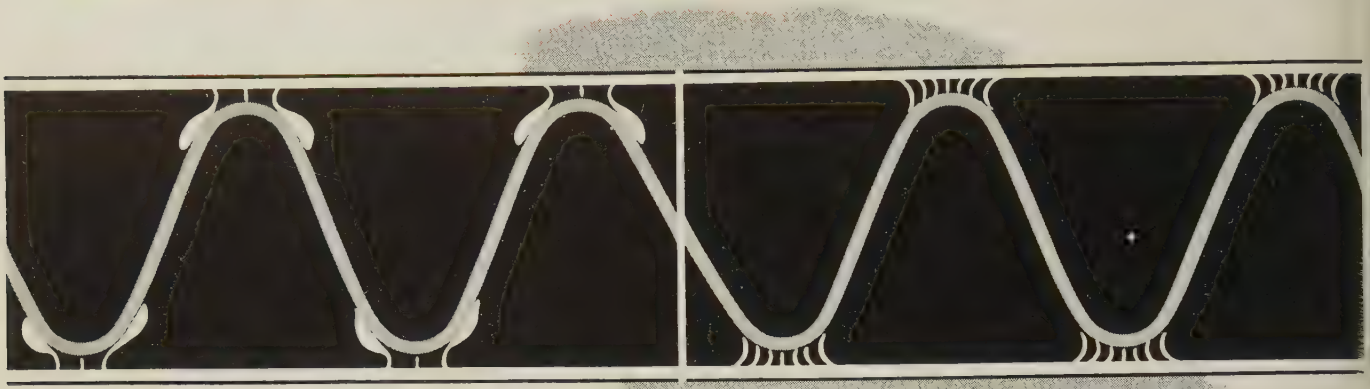

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UNCONTROLLED APPLICATION OF ADHESIVE

1. Excess adhesive.
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1. Less waste . . . adhesive savings.
2. Adhesive where you want it . . . where it's needed.
3. Less adhesive used . . . less moisture to remove.
4. Higher machine speeds.
5. Reduced warping . . . stiffer board.

Only 15/100 of 1% of Kelsize in starch corrugated adhesive is required to give you these important advantages.

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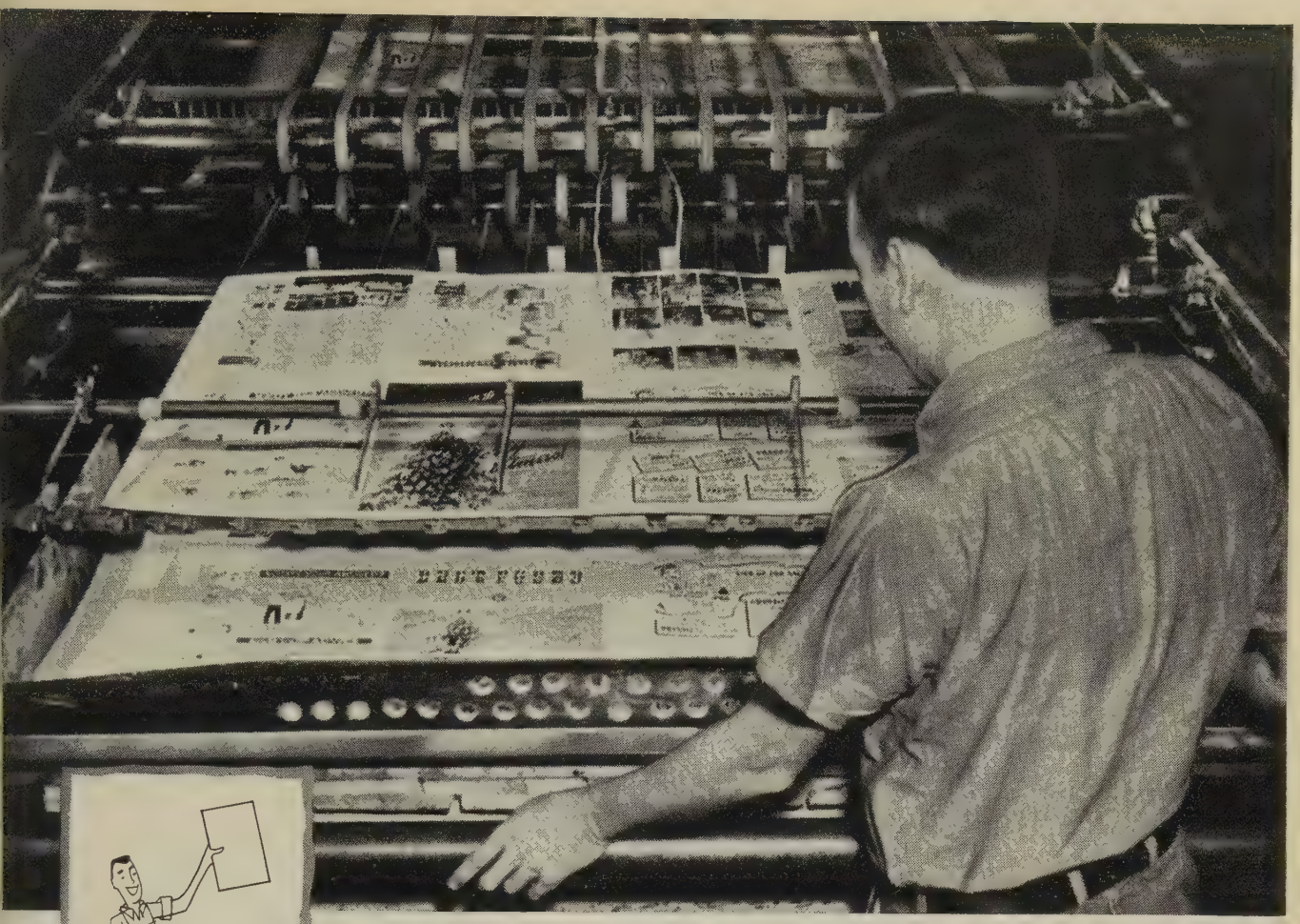

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In addition to reducing "show-through," Celite also improves ink receptivity because its absorptive capacity is higher than that of ordinary wood pulps . . . and far greater than that of any other filler regularly used in paper.

Other ways in which Celite helps you turn out a more printable, more readable paper are by reducing low angle sheen and giving the desired high brightness. And from a production standpoint, Celite can save you valuable man-hours and equipment down-time by controlling the pitch that comes from having to use green wood for pulp.

Why not ask a Celite Engineer to visit your mill and make on-the-spot recommendations for the profitable and economical use of Celite. Just write to Johns-Manville, Box 60, New York 16, New York. In Canada, 199 Bay Street, Toronto 1, Ontario. No cost or obligation.

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FOR THE PAPER INDUSTRY

SEMICHEMICAL PULPING SYMPOSIUM*

Semichemical Process Flowsheets

J. E. SAPP

DURING the ten years from 1940 to 1950, due primarily to the increased demand for such products as corrugating board, insulating board, etc., the production of pulps by semichemical processes more than quadrupled. However, these processes, which consist of a mild chemical treatment followed by mechanical defibering, are by no means limited to the production of coarse products but, in fact, offer a most promising means of utilizing both hardwoods and softwoods in a wide variety of higher quality products. Moreover, they possess a number of other advantages, the most important being that only small amounts of chemicals are consumed and high pulp yields are obtained.

As evidence of the interest in semichemical pulping, many excellent papers have appeared in the literature in recent years, giving detailed data on the preparation as well as the chemical and physical characteristics of both the unbleached and bleached semichemical pulps made from a large number of wood species by different processes (*5, 6, 12–15*).

The purpose of this paper is to review the status of semichemical pulping at the present time with particular emphasis on the two major semichemical processes now in use commercially, i.e., the kraft and neutral suphite, giving flowsheets of several types of installations, in order to show the principal kinds of equipment currently being employed.

THE KRAFT SEMICHEMICAL PROCESS

In the kraft semichemical process which is shown in Figs. 1 and 2, about half the amount of chemical necessary for complete pulping is required to give pulp in the 70 to 80% yield range with the other cooking conditions, such as temperature, total liquor volume, etc., about the same as for a normal kraft cook (*3*). Lower yield pulps such as the "high yield" kraft pulps require more liquor but take less power for defibering and give a stronger, denser sheet; higher yield pulps requiring more power for defibering and giving a weaker, bulkier sheet can be produced by using less liquor. Both conifers and hardwoods as well as mixtures can be pulped satisfactorily. The pulps range in color from only a slightly darker brown than ordinary kraft pulp at the lower yields to a very dark brown at higher yields. Chemical analyses show that, as compared with neutral sulphite pulps of the same yield (75%), kraft semichemical pulps have a higher lignin content but are lower in hemicellulose and extractives (*5*).

Some advantages of the kraft process are that it can easily be used in any existing kraft mill without having to install separate liquor manufacturing or recovery facilities, which makes for low chemical costs, and that with coniferous woods since the alkaline liquor dissolves most of the resinous material, there is very little trouble with pitch.

Disadvantages are the unpleasant odor, the dark color of the pulps, which makes them unsuitable for some uses, the lower yields for a given lignin content, and with some species of wood, the fact that neutral sulphite pulps give a board of greater rigidity which is of much importance in corrugating board.

Figure 1 illustrates a semichemical pulping system in which existing kraft mill stationary digesters and diffusers are used for cooking and washing. In this system the wood is barked, chipped, and screened, the oversized chips rechipped in a hammermill shredder, and the fines and bark burned. The chips are conveyed by belt conveyor to overhead bins from which they are dropped into the digesters and are cooked with about 7% active alkali (as Na_2O) using a cooking cycle of 1 hour to 100 p.s.i. and $1^1/_2$ hours at 100 p.s.i. The softened chips are then blown to the diffusers, washed, dumped, and pumped to an agitated storage tank located near a disk refiner system. From the tank they are pumped to a regulating box which discharges to a set of drainer conveyors which in turn discharge the dewatered chips at about 8% consistency to primary disk refiners. After passing through the primary refiners and diluting in the primary chest to approximately 3.5% consistency the pulp is fed to a second set of disk refiners to complete the defibering and partially refine the pulp prior to sending to the jordans and paper machine. Screens may also be used after either defibering stage, but are not essential unless the pulp is to be used in some application such as bleaching, and are not shown in this or the following diagrams.

This sytem achieves an efficient utilization of existing equipment, a fair liquor recovery (about 80%), and yields a relatively clean, well-defibered pulp. However, liquor losses are higher than if the chips were defibered before washing, the liquor remaining in the pulp going to the machine causes difficulties with foam and, in addition, the chips are cooled to a certain extent by the washing and dumping so that they are less pliable and more difficult to defiber than if they had been defibered while still hot.

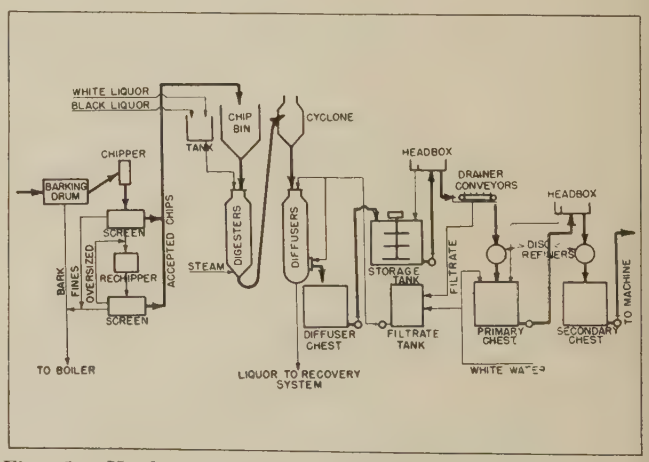
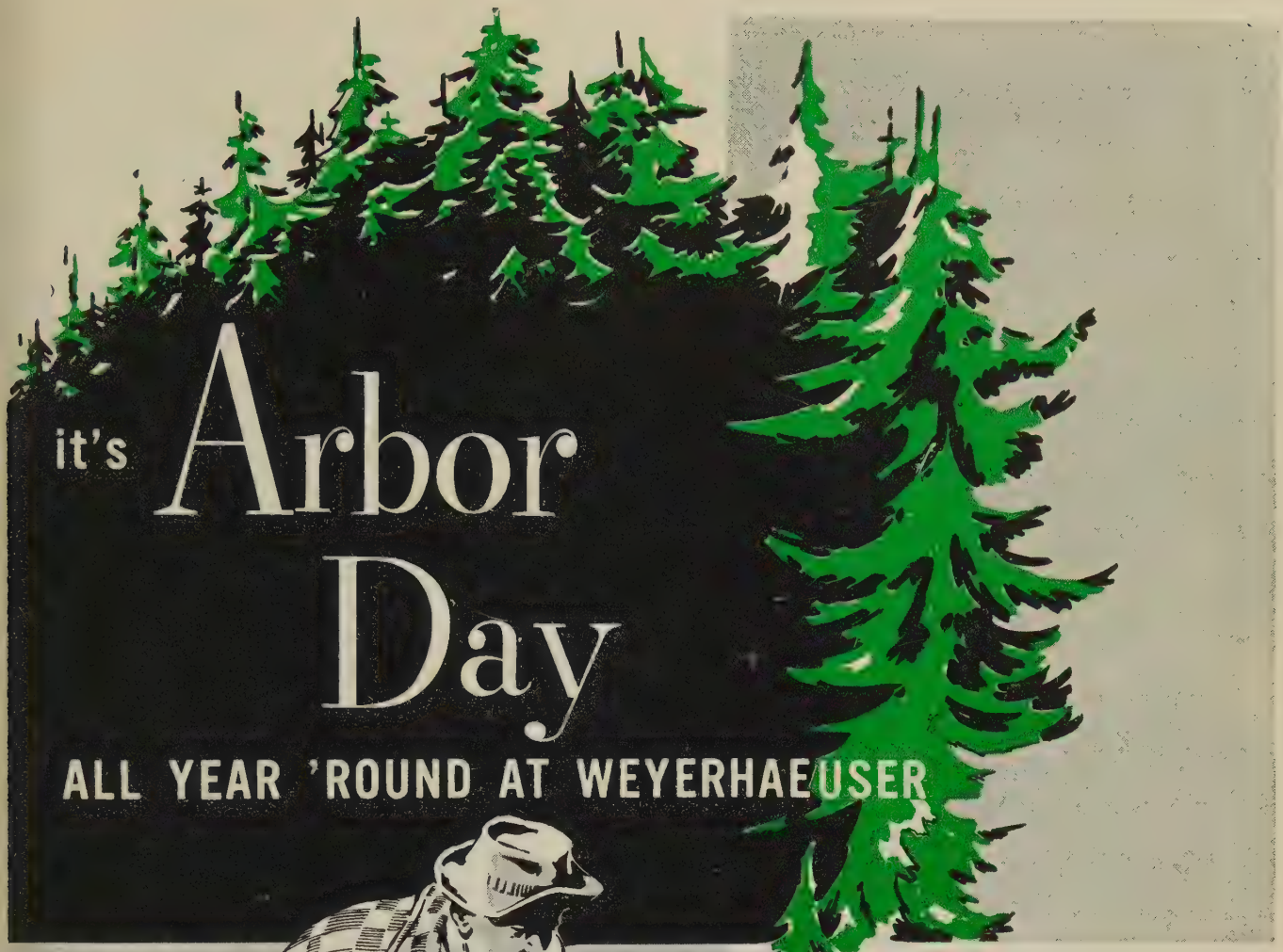


Fig. 1. Kraft semichemical process using stationary digesters and diffusers

Figure 2 illustrates a system in which kraft semichemical pulp for use in corrugating board, wallboard, etc., is produced continuously in a Chemipulper. In the system shown, the wood is not barked but instead is fed directly to a disk chipper, from which the chips go to vibrating screens where the over-

J. E. SAPP, Chemical Engineer, Gaylord Container Corp., Bogalusa, La.

* Presented at the 37th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 20, 1952.



ARBOR DAY was started in Nebraska 79 years ago by J. Sterling Morton to stimulate interest in tree planting. Since 1941, through its Tree Farms, the Weyerhaeuser Timber Company has made a large-scale practical business of reforestation.

Most Weyerhaeuser Tree Farms are located west of the Cascade Mountains, which is Douglas Fir country. In these forests, nature, with man's help, reseeds the harvested lands. Thousands of seeds are carried from the ripened cones of mature trees which are left standing in groups, strips or blocks by Weyerhaeuser loggers. This system of harvesting is called *block logging*, and leaves a patchwork pattern of cut and uncut areas.

Where seed trees and seedlings have been destroyed by forest fires, Weyerhaeuser Foresters must plant seedling trees. This is slow, hard and costly work, and fortunately less than 3% of Weyerhaeuser Tree Farm lands require hand planting.

As mature timber is logged in the forests under Weyerhaeuser management, the harvested land begins growing new trees. Thus, Weyerhaeuser Tree Farm lands will continue to produce successive timber crops.

PULP DIVISION **WEYERHAEUSER**

sized chips are removed and rechipped but, unlike the system of Fig. 1, the fines are retained for pulping. The accepted chips are conveyed to a silo and from the silo to a bin situated over the Chemi Pulper. From the bin, the chips are fed by a tapered screw conveyor into the B.K. (Beveridge-Kehoe)

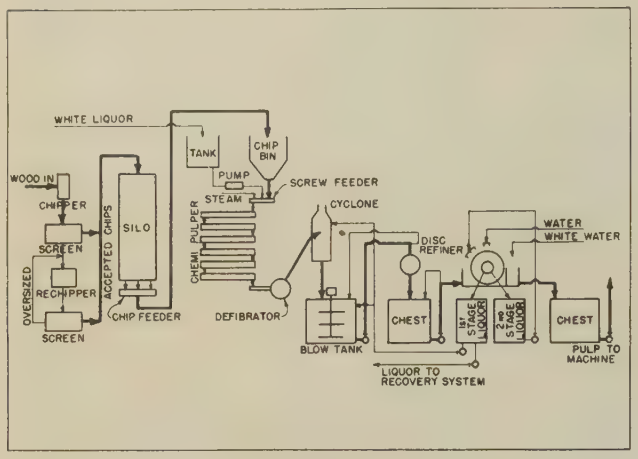


Fig. 2. Kraft semichemical process using continuous pulping

reaction chamber, which in this instance consists of six pipes, each 24 inches in diameter by 19 feet long. White liquor is fed in just ahead of the reaction chamber, followed by 150 to 175 p.s.i. steam. After passing through the B.K. reaction chamber, the chips are discharged through a defibrator into a cyclone from which they drop into a blow tank. The partially defibered pulp is next pumped through disk refiners to a two-stage vacuum washer, to complete the defibering and washing.

Some of the advantages of the continuous system are its economy in building space, the easy controllability of cooking conditions, and uniform boiler load requirements. Also since pulp, rather than chips, is blown to the blow tank, subsequent handling and washing are facilitated. Some of the disadvantages are the high cost of such a system, the crushing action of the screw on the chips, which action has been found to adversely affect pulp quality (*1*), and the short retention time in the cooking zone. As for the use of unbarked wood, as in this layout, the wood economy is obviously good since a certain amount of pulp will be obtained from the bark. However, with many species of wood, the quality of the pulp will be seriouly lowered (*8*).

THE NEUTRAL SULPHITE SEMICHEMICAL PROCESS

In the neutral sulphite process, which is shown in Figs. 3 and 4, the cooking liquor is usually a mixture of sodium sulphite and sodium carbonate or bicarbonate, the sodium sulphite being the major component serving to delignify the wood with the sodium carbonate or bicarbonate the minor component serving to neutralize excess acidity, thereby preventing acid hydrolysis of the pulp as well as minimizing corrosion. Other chemicals with an alkaline reaction such as sodium sulphite and sodium hydroxide may also be used as the minor component (*9*). The amount of sodium sulphite required for pulping to a yield of 75% is usually in the range of 7 to 15% on the basis of the oven-dry wood. The amount of carbonate is generally about $^1/_5$ to $^1/_2$ the quantity of sulphite, depending upon the species of wood, the residual alkalinity desired, and the amount of sulphite used, being lower the higher the quantity of sulphite.

Cooking cycles of 1 to 3 hours at 100 to 125 p.s.i. steam pressure are satisfactory, though there is wide variation in the cycles which are used throughout the industry.

The pulps produced are light in color, varying to a certain extent with the species of wood used, the degree of cooking and the amount of alkali used along with the sulphite, increased alkalinity tending to give a darker pulp.

The lighter color of the neutral sulphite pulp is an advantage in the manufacture of many types of products. Also, as mentioned in the preceding section, the neutral sulphite process has other advantages such as being of less offensive odor, giving a higher yield at a given degree of delignification and, in some cases, giving pulps of better strength properties.

Some of the disadvantages are the troubles which are often encountered with pitch and slime formation as well as the difficulty of liquor recovery. At present, the waste liquor is either ditched (except such as can be recycled to subsequent cooks) or else a cross recovery process is used in which the neutral sulphite waste liquor is substituted for part of the saltcake make-up in a kraft recovery system. Ditching is unsatisfactory both from the economic viewpoint and from that of stream pollution. Cross recovery with kraft liquor is satisfactory but the amount of neutral sulphite liquor that can be recovered is limited by the saltcake requirement and also, if the minor component of the neutral sulphite liquor contains no sulphur (such as soda ash, for example) the sulphidity of the white liquor is lowered.

Figure 3 shows an installation, similar to a number in which neutral sulphite semichemical pulps are currently being produced from various woods such as gum, poplar, chestnut, etc. In this installation, the wood is put through a drum barker, from which it is conveyed to a disk chipper. The chips are not screened but are taken directly to storage bins located above the digesters which are globe rotaries.

Cooking is on an approximately 6-hour total cycle at 100 p.s.i. pressure, the digesters being rotated periodically during a cook. The cooking liquor is a mixture of sodium sulphite, bicarbonate, and carbonate, produced by burning sulphur and absorbing the SO_2 gas in soda ash solution, the total quantity of chemicals charged amounting to approximately 9 to 10%, based upon the weight of oven-dry wood. At the end of the cook or, in some cases, after a period of impregnation at the beginning of the cook, the excess liquor is blown to a storage tank. After completing the cook the softened chips are dumped from the rotaries into leach casters (tanks equipped with a rotating rake mechanism for discharging the chips through a hole in one side of the bottom) which feed a set of primary disk refiners via Redler and variable speed screw conveyors. After this first stage of defibering, the pulp is diluted to about 3% consistency, utilizing strong

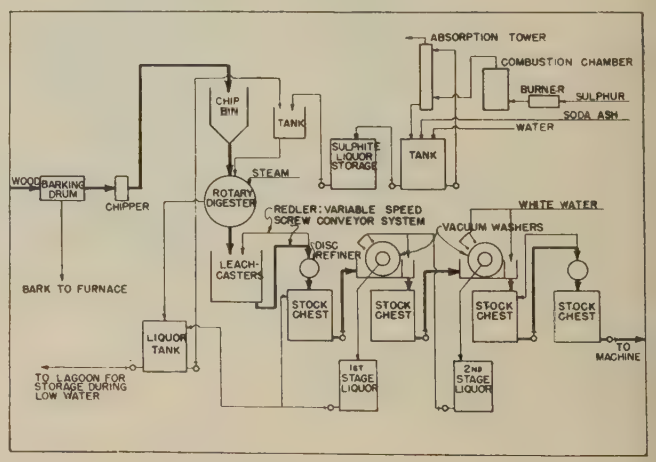


Fig. 3. Neutral sulphite semichemical process using globe rotary digesters

liquor as diluent, then is washed on a two-stage vacuum washer system and put through a second set of disk refiners.

Some advantages of this layout are that it produces a high quality, uniform product and that the hot, softened chips in damp form rather than in suspension can be fed to

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the disk refiners at high consistency and at a uniform rate by the leach caster-conveyor system. The washing system is efficient giving a clean well-defibered pulp going to the machine.

Some disadvantages are the higher labor costs of rotaries as compared to stationary digesters as well as their greater

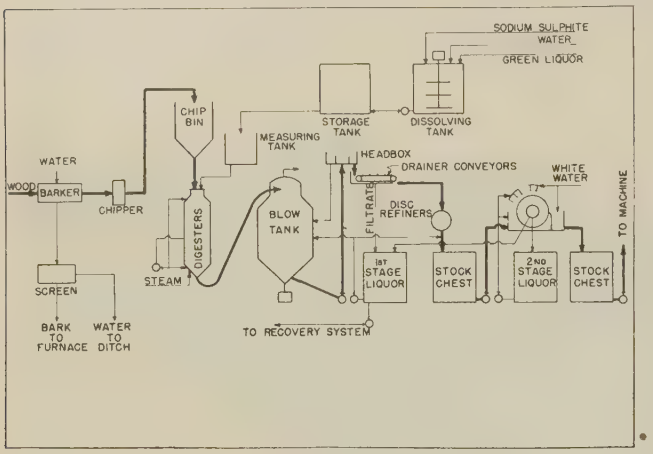

Fig. 4. Neutral sulphite semichemical process using stationary digesters with blow tank

maintenance costs. Also, in this particular case the waste liquor is lagooned then ditched during high water, though it could obviously be used in a kraft recovery system if such were available.

The last type of installation of importance at the present time, not only in semichemical pulping for corrugating board, but also with slight modifications in high yield kraft pulping, is shown in Fig. 4. In this system, which is an integrated neutral suphite-kraft pulping operation, the wood is barked in a hydraulic barker, chipped in a disk chipper, and the chips sent directly to overhead chip bins without screening. From the chip bins the chips drop into stationary digesters where they are pulped with neutral sulphite liquor made by dissolving sodium sulphite in green liquor. The quantity of chemicals used is approximately 12% of the oven-dry weight of wood and the cooking cycle 1 hour at 125 p.s.i. and $2^1/_2$ hours at 125 p.s.i. The chips, after cooking, are blown to an agitated blow tank from which they are pumped to a headbox feeding a set of drainer conveyors. These, in turn, feed the dewatered pulp to disk refiners, after which the defibered pulp is diluted to about 3% consistency in the refiner chest and pumped to a two-stage vacuum washer, the clean pulp being then sent to the paper machine system and the recovered liquor to the kraft recovery system.

This type of layout is a more modern version of that shown in Fig. 1 and possesses the additional advantages of more efficient washing, lower labor costs, and of defibering hot stock rather than stock cooled off in diffusers. Moreover, by using the waste liquor in the kraft mill recovery system the liquor costs are lowered considerably, and using green liquor in the neutral sulphite cooking liquor instead of soda ash or bicarbonate, not only are liquor costs further reduced, but also a larger ratio of neutral sulphite to kraft production is possible and the sulphidity of the kraft liquor is kept up.

CONCLUSION

Thus, from the preceding discussion it is apparent that there is considerable diversity in the mechanical layouts now in successful use in semichemical pulping and that each has advantages which under a given set of circumstances might dictate its use. There are also many other possibilities both as regards pulping agents and mechanical procedures which may be used. For example:

1. A neutral ammonium sulphite process has recently been used fairly successfully at several mills, interchangeably with the neutral sodium sulphite process, during a period of soda ash shortage (*7*). While some difficulties were encountered, the process is, nevertheless, a practical one and might possess decided advantages insofar as the ease of liquor recovery is concerned.

2. High yield acid sulphite pulping is also feasible and is being done on a commercial scale (*16*).

3. The cold soda process developed at the Forest Products Laboratory has given very promising results both on a laboratory scale and in mill trials (*4*).

4. The mechano-chemical process for simultaneously cooking and defibering agricultural residues also appears to be a very promising method, suitable for use with a number of different chemicals as well as many raw materials (*2*).

5. The Chemigroundwood process developed at the New York State College of Forestry adapts semichemical pulping to wood in block form, which then may be ground with a low power consumption to give a high yield of pulp from hardwoods, superior in strength to spruce groundwood (*10*).

6. Semichemical pulps, when bleached, give very high yields (50 to 60%) of pulps, which are easy to refine, have exceptional strength properties, and are suitable for a number of uses such as book paper, bond paper, writing, glassine, etc.

7. A number of variations of the cooking process are available for producing pulps of different physical qualities, such as prehydrolysis if a soft, absorbent pulp is desired, etc. (*11*).

Undoubtedly these processes, with their great flexibility, their economy both in wood and chemical consumption, their wide applicability to different wood species, and their suitability for manufacturing pulps of many different properties, will play an increasingly important role in the future particularly as their potentialities become more fully understood and as pulpwood supplies become scarcer.

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While the above flow diagrams have been altered so as not to correspond exactly with any known mill, they are similar to a number now in existence and were prepared with the aid of data very kindly furnished by the following persons: S. I. Aronovsky, Northern Regional Research Laboratory; Richard G. Coker, Sonoco Products Co.; L. R. Growdon and George Pringle, The Mead Corp.; J. A. Hanna and R. L. Weldon, Bathurst Power & Paper Co.; Franklin Jones, St. Joe Paper Co.; W. R. Nelson, Green Bay Paper & Pulp Co.; and R. S. Wertheimer, Longview Fibre Co.

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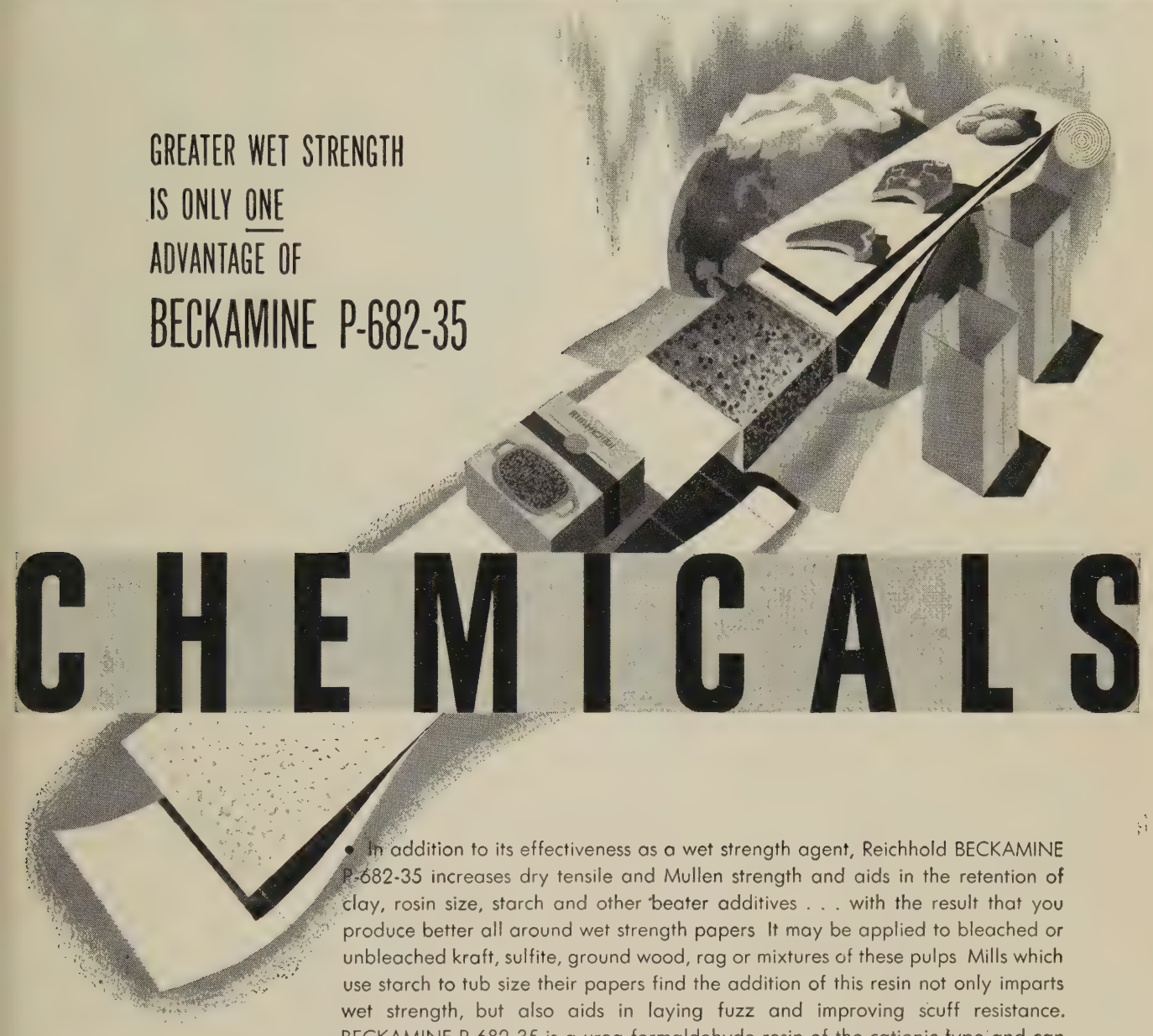

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Uniform Coooking by a Continuous Semichemical Process

A. P. YUNDT

In most parts of the United States the demand for hardwoods is less than the supply incidental to softwood cutting operations. To prevent cut-over land from reseeding in hardwoods, no hardwood seed trees may be left standing. This necessitates either a costly girdling and poisoning operation, or finding an economic large-scale use for the hardwoods.

At Camp Manufacturing, the soft hardwoods, largely gum, are straight kraft pulped for use in a wide variety of papers. The hard hardwoods, largely oak, are not equally satisfactory. The manufacture of a 9-point corrugating medium from oak semichemical pulp seemed to hold promise.

A survey of opinion among semichemical corrugating board manufacturers indicated that, though oak was an acceptable raw material, it was less desirable for the purpose than most other available hardwoods. Accordingly, if this course were to be followed, it seemed prudent to use the best possible pulp-making techniques.

Batch cooking permits allowance of adequate time for the penetration of the cooking chemicals before cooking temperature is reached. Accordingly, uniform cooking is possible. However, subsequent refining of the softened chips can be economically done only after blowing to atmospheric pressure and hence at temperatures below 212°F. Because semichemical pulps contain a high percentage of thermoplastic lignin, they defiber more readily at a higher temperature.

Continuous semichemical pulping permits economic primary refining at full cooking temperature as well as savings in investment, labor, and steam. However, as normally practiced, the cooking is very nonuniform. This is readily demonstrated by the use of the phloroglucinol groundwood test reagent (TAPPI Standard T 401 m-42). Many of the fibers in a sheet made from such pulps stain a deep red. The usual screw plug chip feed steam seal breaks up the chips to allow more ready penetration (and incidentally does much fiber damage). It is overly optimistic, however, to expect the chemicals to uniformly penetrate the chips and perform the pulping all in about 10 to 15 minutes' time. Instead, the outside of the chip is overcooked, and the liquor is exhausted before it penetrates to the center of the chip.

DEVELOPMENT

An attempt was made to combine the best features of both of the above processes. The method finally developed consisted of the following steps:

1. Presteam the chips at atmospheric pressure to drive out the air.
2. Displace the steam with a solution of cooking chemicals. Any steam in the chip pores is condensed and penetration is thus not hindered by air. Hydrostatic pressure is therefore not required. Soaking is continued for about 4 hours to be sure the chemicals are uniformly distributed throughout the chip. The required strength of soaking liquor may be empirically determined to give the desired final result.
3. The soaking liquor is then drained from the chips and may be refortified for soaking a new batch.
4. The drained chips are introduced into a conventional continuous cooker by means of a rotary valve in lieu of the usual screw feed (which would squeeze out some of the cooking liquors).
5. Cooking and defibering are then carried out in the conventional manner for continuous semichemical pulping except that the cooking time and/or temperature may be reduced because penetration is already accomplished.

The above procedure was tested insofar as possible in the laboratory with promising results. Unfortunately, many questions could be answered only by tests on mill size equipment. No pulp mill readily adaptable to this process could be found. Accordingly, the smallest practicable unit, a 50-ton per day "pilot plant" was designed and built.

THE PLANT

Because kraft white liquor and a kraft recovery system for the wash liquors were available, its use was very desirable. The equipment was fabricated of corrosion-resistant materials, where necessary, to provide for possible future use of neutral sulphite. Accordingly, no corrosion problems have thus far appeared.

The steaming and soaking are carried out in leach casters with perforated false bottoms of stainless steel. They were used instead of a continuous steaming and soaking tower because they gave greater flexibility of operation in case changes in operating procedure seemed desirable, and because satisfactory operation was assured. Enough difficulties were anticipated with the other experimental aspects.

The drained, impregnated chips are discharged continuously from one of the four soaking tanks and conveyed past a magnetic separator to a small hopper over the rotary feed valve. The valve is essentially an oversize continuously rotating plug-cock with two large pockets on either side of the plug instead of a hole bored through. The upper pocket fills with chips and then dumps when the valve rotates a half turn. The other pocket, now at the top, simultaneously fills with chips, and the process is repeated.

The cooking chamber is a single horizontal tube 33 inches in diameter and 22 feet long with a double-flight screw. It discharges by gravity to a smaller screw to uniformly feed the Asplund Defibrator. The rotary valve, cooker, defibrator, and blow valve were designed by American Defibrator, Inc.

The crude fiber is collected in a cyclone, washed out with black liquor, and given a secondary refining in an 48-inch Sutherland. The blow steam heats the pulp to above 200°F. which aids refining. Washing is by a two-drum four-stage Swensen vacuum washer. Black liquor to recovery is about 7° Bé.

THE PULP

Because gumwood chips were on hand and easier to pulp to a satisfactory product, the mill was started up on gum and most of our experience to date is on that wood. Lately, we have been changing over to oak and find the chemical requirement slightly more, and the pulp is much more difficult to jordan. However, it has been found desirable to use less chemical instead in order to maintain the flat crush test with the finer, and hence inherently more flexible, oak fibers.

A typical pulp prepared from green fresh gum chips was made by steaming 20 minutes and soaking in diluted kraft white liquor 4 hours at 180°F. The liquor analyzed 32 grams per liter of NaOH expressed as Na_2O and 9 grams per liter of Na_2S as Na_2O. The alkali pickup of the chips corresponded to about 6.8% Na_2O on the basis of the dry wood. Cooking of the drained chips was for 12 minutes at 110 p.s.i. Lignin content was 18.6% and yield was estimated at 73% on the basis of laboratory cooks. Excellent defibering was obtained with only 5 hp.-days per ton. It was made into corrugating board with a flat crush of 45 p.s.i.

INFLUENCE OF SOAKING TEMPERATURE

High soaking temperatures considerably reduce the soaking time required to give satisfactory uniformity of penetration, especially in the case of alkaline liquors. Alkalies swell the fiber structure and thus partially close the wood pores. The increased thermal agitation at the higher temperatures breaks up the hydration of the ions thus decreasing the swelling action when they combine with the carbohydrate matter. The rate of diffusion of particles, including ions, obeys the following equation (*1*):

A. P. Yundt, Technical Adviser, Camp Manufacturing Co., Inc., Franklin, Va.

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where

D = the number of moles which diffuse across a unit area in unit time for unit concentration gradient
R = the universal gas constant
T = the absolute temperature
η = the viscosity of the medium
r = the mean radius of the particles
N = Avogadro's number
K = constant

With increasing temperature, T, the viscosity decreases and so does the mean radius of the particles because they are less hydrated. Thus the rate of diffusion increases rapidly with increasing temperature.

APPLICATIONS

By screening the pulp and re-refining the rejects, it is possible to make a shive-free pulp of over 700 ml. Canadian Standard freeness. The color is quite good, being equal to standard pine kraft chemical pulp if the final pH of the cook is kept above 9.5, and becomes progressively darker as the pH is lowered, being a chocolate brown for a final pH of 8. Because so little force is required for defibering, there is little breakage or other fiber damage. The pulp appears satisfactory for use in paper towels and perhaps as a minor constituent in such grades as grocery bag in addition to its primary use in corrugating medium. For the latter product, we have found it unnecessary to add any softwood fiber, though we do add about 2% in the form of refined screening rejects from the kraft mill.

No commercial runs have been made using neutral sulphite liquors, but laboratory tests using a soaking liquor containing 240 grams per liter of sodium sulphite and 60 grams per liter of sodium carbonate were very promising. Cooking time was 30 minutes at 140 p.s.i. The yield was 70% of a strong pulp of good color. The relative ease of producing shive-free pulp of high freeness and low fiber breakage should make it an ideal source of pulp for bleaching. The two kraft semichemical pulps tested so far have had relatively low strength when bleached.

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Semichemical Pulping Using Kraft Liquor

E. M. LEAVITT

This past July the semichemical plant of North Carolina Pulp Co. in Plymouth was put in operation.

The semichemical operation is a separate unit from the rest of the mill, from the woodyard through the paper machines. Provisions have been made for the installation of a barking drum which has not yet been delivered. At the present time wood goes through a six-knife chipper to a chip silo and is fed from the chip silo with a vibrating feeder to the belt conveyor system which delivers the chips to the digesters. This conveyor has a 36-inch magnet over it to remove tramp iron. The black and white liquors are metered automatically to a liquor charge tank. The liquor is pumped from the charge tank to the digesters. The digesters are blown with remote control blow valves to a conventional blow tank equipped with a consistency regulator. Stock, or rather the chips, pass from the blow tank through two cyclifiners in series. Then it is pumped through a header to two primary disk refiners in parallel. The stock that is not taken off at the refiners is returned to the bottom of the blow tank. Stock that passes through the primary disk refiners is pumped through a second header and most of it passes through the secondary disk refiners, of which there are two in parallel. The stock that is not passed through the secondary refiners is also returned to the bottom of the blow tank. Stock from the secondary refiners drops into the refined stock chest.

The refined stock chest is built very much like the blow tank with an agitator and consistency controller and conical bottom. The consistency through the refiners is maintained at approximately 6%. From the refined stock chest, stock is pumped to a three-stage set of vacuum washers and is then passed over the decker and pumped to the paper mill.

Provisions were made for the use of rotary screens between black liquor washers and decker; however, the screens were not necessary.

This semichemical plant was designed so that one man standing in front of the instrument panel would be able to observe the operation of the refiners and the black liquor washers, as well as the instruments which control the blow valves, liquor and stock levels, control lights on chip conveyors and vibratory feeder on chip bin, and observe the filling and capping of the digesters. This man can control his stock flow to his refiners and refiner settings and all the valves and control points on his washer system by not moving more than 30 feet from the front of the control panel.

The operation of this plant requires one operator and one helper, whose responsibility is to take the chips from the chip silo, load the digesters, operate the refiners and washers, and other incidental jobs necessary to keep the plant operating; as well as the necessary cleaning and wiping for good housekeeping.

Yield from the 3300-cubic foot digesters is approximately 15 tons of pulp.

The semichemical plant has operated since July making pulp for 9-point corrugated board. The plant was started before the woodyard conveyors arrived, and all pine chips were trucked over for about 30 days. Since the first of September, the plant has operated part time on 50% hardwood and 50% pine, and part time on 100% hardwood. The hardwood consists of 80 to 90% gum, the rest—oak, poplar, and other assorted hardwoods.

The operation of the digesters has gone through quite a cycle, from 8 hours' cold soaking with the liquor, plus 4 hours' steaming at 40 pounds' pressure, to 1 hour cold soaking and bringing up to 40 pounds in 1 hour and blowing—a total of 2 hours. The chemical charge has varied from 20% active as Na_2O based on moisture-free wood to the use of kraft mill black liquor with no additional active.

The refiner operation has varied from a very well-refined stock with a freeness of 60 to 70 seconds to a very rough-appearing stock of 10 to 15 seconds on the Williams slowness tester.

At the present time the plant is operating using 100% hardwood, 9% active NaOH figured as Na_2O based on moisture-free wood, cold soaking 1 hour bringing up to 40 pounds in 1 hour and blowing, refining to a freeness of 10 to 15. The rejects from the kraft side which are all pine are refined and added to the semichemical pulp in the paper mill. The furnish to the paper machine is in the neighborhood of 85% semichemical pulp and 15% refined pine rejects.

The cooking liquor used is regular kraft liquor. The black liquor from the washers is returned to the regular kraft 7° liquor tanks.

The operation of this plant is very flexible. It can be operated continuously from 50 to 200 tons per 24 hours with the equipment as installed. The quality of pulp produced can be modified kraft pulp or semichemical pulp.

E. M. Leavitt, General Superintendent, North Carolina Pulp Co., Plymouth, N. C.

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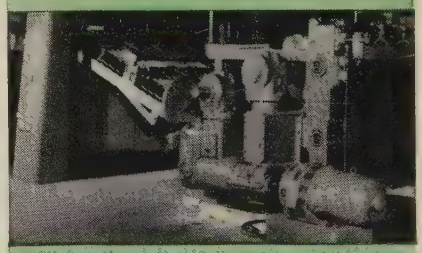

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Received Feb. 3, 1952. Presented at the 37th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 18–21, 1952.

Semichemical Pulping—a Process Study

C. WILLIAM CONVERSE

Seldom has a pulping process expanded so rapidly in the same period of time as the semichemical processes during the past five years. Semichemical pulping has been a commercial entity since 1925, but it was relatively insignificant and its growth rate was slow until after 1945. Table I indicates the trend.

In the five years, 1946–50, production capacity increased by 141%. The construction programs under way in the industry will, within two years if not retarded by the national emergency, increase production by at least 50% over 1950. Behind this expansion are compelling economic advantages. A few of these advantages are:

1. The semichemical processes use the readily available hardwoods particularly aspen and birch in the north and the gums in the south; woods whose present utilization does not keep pace with their annual growth increment in most areas. By the use of these locally available species, the dependence of many mills on foreign or long-haul wood or on market pulp can be reduced or eliminated. Thus, the semichemical processes open the door to the full utilization of the hardwood species. This is especially important in the North where, from New England to Minnesota, the conifers when cut have been largely replaced by

Table I

Year	*No. of companies*	*No. of mills*	*Tons per day*	
1925	1	1	10	
1930	2	6	355	
1935	2	6	355	
1940	..	..	460	
1945	6	10	925	
1950	15	21	2500	
1951	..	..	2750	preliminary

Source: U. S. Forest Products Laboratory and U. S. Pulp Producers Association.

hardwoods, chiefly aspen but including birch, beech, maple, oak, and others. The conifers now constitute only about 25% of the total timber volume in this area. Aspen is a fast-growing tree and produces a much higher yield of cellulose per acre per year than the conifers it has replaced, thus assuring many mills of a perpetual wood supply within a reasonable hauling distance.

2. The yield of pulp per cord is much higher than that obtained by the usual processes. The unbleached yield varies from 70 to 80% and bleached pulps are produced in yields of 55 to 60%. Moreover the density of the hardwoods, except alder and aspen, is much greater than that of the conifers, an advantage when wood is purchased by volume since a far greater pulp production per cord is obtained (Table II).

3. The capital cost of a semichemical pulp mill can be much lower than that of a regular pulp mill. The cooking chemicals used in the neutral sulphite process can be purchased in crystalline form if the size of the mill does not justify a liquor making system. A complete liquor preparation system costs much less than for equal tonnage systems for fully cooked pulps.

4. High-grade unbleached and bleached pulps are suitable for use in a wide range of paper and board grades. While the unbleached pulp is particularly well suited for corrugating board because of its rigidity, the better grades are finding increasing use in a variety of boards and papers.

C. William Converse, Manager, Pulp & Paper Mill Div., Sprout, Waldron & Co., Inc., Muncy, Pa.

Table II

Wood species	*Moisture-free weight, lb./cu. ft.*	*Bleached pulp yield, lb./cu. ft. wood* — *60% Yield neutral sulphite*	*40% Yield acid sulphite*
Red alder	24	14.4	..
Aspen	22	13.2	..
Birch and beech	34	20.4	..
Hickory	35	21.0	..
Maple	32	19.2	..
Gum	31	18.6	..
Oak (white)	42	25.2	..
Oak (red)	39	23.4	..
White spruce	24	..	9.6
Hemlock, E. and W.	25	..	10.0
White fir	24	..	9.6

The approximate wood volume of a cord is 90 to 95 cubic feet.

The development of commercial bleached pulps has been an important milestone in the neutral sulphite process and it seems likely that the production of bleached pulp will some day equal or surpass that of unbleached pulp.

Uppermost in every papermaker's thoughts about semichemical pulp is the question: "How can I use this pulp in my grades?" Until 1948, all semichemical pulp went into 9-point corrugating board. Of the 2300 tons per day produced during 1950, about 2200 tons went into 9-point corrugating board. Of the remaining 100 tons, about 75 tons bleached went into coated magazine paper, 10 tons bleached into specialty coated paper and board, and 15 tons unbleached into specialty boards. Semichemical pulp has many characteristics which make it well suited for use in a wide range of papers and boards. It acts as a short fiber in its ability to give excellent formation and as a long fibered pulp in its high strength. The characteristics of semichemicals pulps have been described by Murtfeldt (*1*) as follows "The unbleached semichemical pulp is characterized by initially high bursting strength, high tensile, and medium to low tear as compared to spruce or balsam acid sulphite. A high hemicellulose content causes rapid hydration when beaten. For many purposes, the pulp can be considered prehydrated with many of the characteristics of softwood acid sulphite pulp at the same degree of development. The unbleached and the single-stage oxidation bleached fibers are quite straight and form a stiff sheet as compared to sulphite. The fully bleached pulp is higher in burst, tear, and tensile, and the fibers are more flexible compared to the unbleached pulp. The drainage characteristics of semichemical pulp lie between groundwood and sulphite. Its prehydrated quality and its ability to form well with other fibers make it a new and useful ingredient for many paper furnishes."

Table III illustrates the improvement in pulp strength through bleaching. Note that these figures are not initial strength values but are those for a particular freeness value, namely, 350 ml., Canadian Standard. The figures are compared to bleached softwood acid sulphite.

The most important problem in extending the usefulness of semichemical pulp is to completely eliminate the shives and dirt. Equipment and process design are available to do this and at least two prominent U. S. manufacturers of bond, writing, and printing papers are making and using bleached semichemical pulp. Also, a pulp mill is under construction which will make bleached semichemical pulp for glassine papers. Since these users require pulp of the highest quality, these examples indicate the high level to which semichemical pulp quality has been developed.

A still newer development, one of many to come, is the use of semichemical pulp in newsprint in place of unbleached sulphite.

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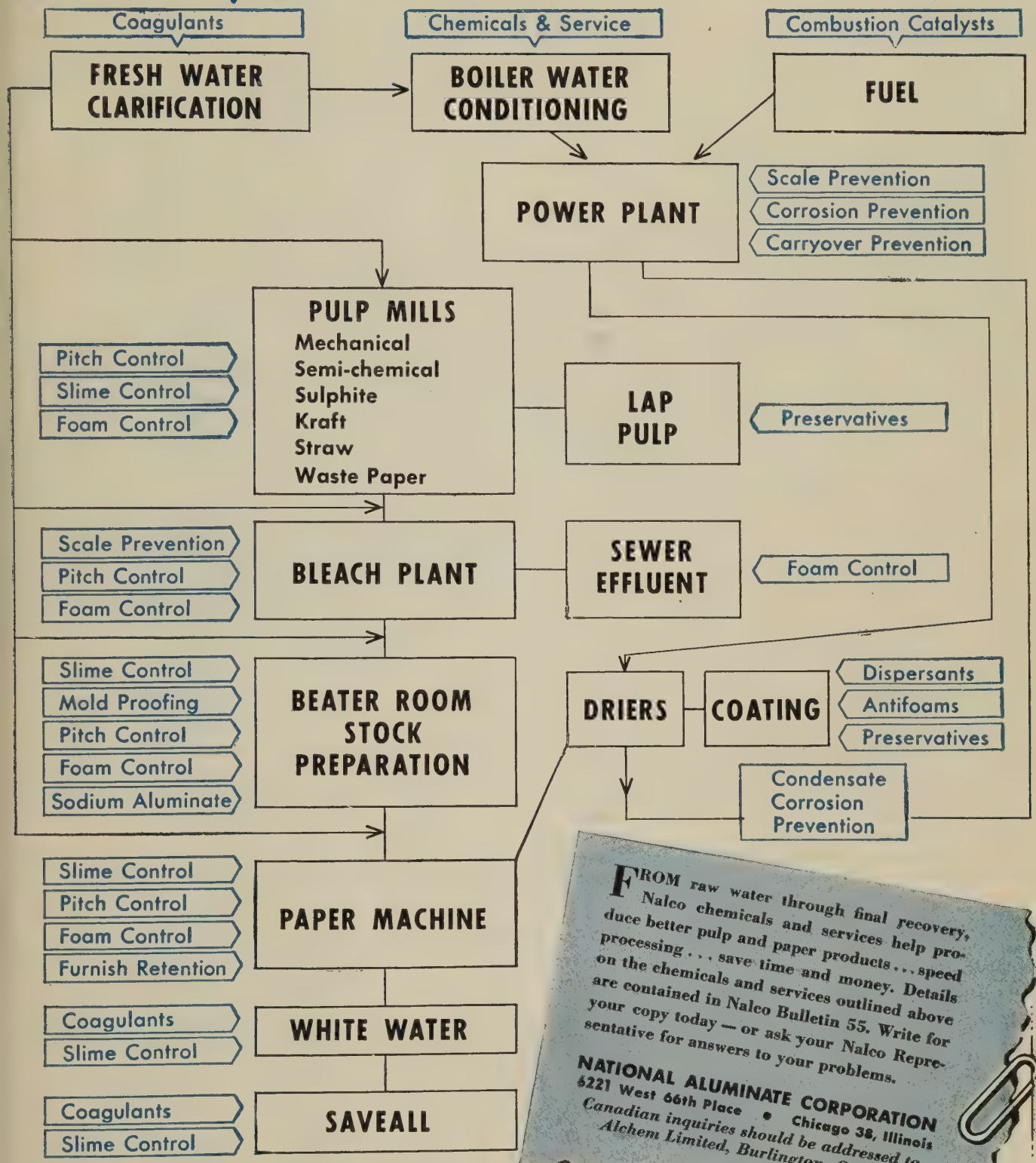

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PROCESSES

Fundamentally, the semichemical pulping processes consist of a mild chemical cook followed by mechanical fiberizing which completes the reduction of the chips to fiber. Yield on the wood basis is usually in the range 70 to 80%. This definition covers two commercial processes, namely: the neutral sulphite semichemical process and the sulphate semichemical process. In the former, the cooking liquor consists of sodium sulphite buffered with sodium carbonate or bicarbonate to maintain an alkaline condition throughout the cook. Where corrosion-resistant equipment is employed, less buffer may be used so that the cooking liquor is slightly acid at the end of the cook. A softer chip and a brighter pulp are produced under these conditions. A variation of this process is the use of ammonium sulphite buffered with ammonium hydroxide. The sulphate semichemical process, as the name implies, uses sulphate cooking liquor but in a concentration insufficient to completely digest the chips. Occasionally, caustic soda alone is used as the cooking chemical. To these processes, a third can be added since it is now used on a commercial scale: the cold caustic semichemical process in which the chips are treated with a caustic soda solution at room temperature for several hours after which the chips are mechanically pulped. The concentration of the solution is 2.5% for aspen but up to 7.5% may be necessary for dense hardwoods. Of these processes, only the neutral sulphite has been used, thus far, in the commercial production of bleachable pulps.

The cooking chemicals for the neutral sulphite process are usually purchased in crystalline form although some mills make their cooking liquor by burning sulphur and absorbing the SO_2 gas in a sodium carbonate (or ammonium hydroxide) solution sprayed in the top of a ceramic packed absorption tower. The liquor preparation system is simple, easy to operate, and far less expensive than those of the regular pulping processes.

Spent liquor is often used for make-up in succeeding cooks. Its chemical value in the neutral sulphite process is negligible but the heat recovery is advantageous. There is, as yet, no practical system available for the recovery of the cooking chemicals unless the semichemical system is operated in connection with a kraft mill. In that case, the spent liquor, whatever the process, is disposed of in the kraft recovery system. Research on recovery processes must eventually lead to a practical solution of the waste liquor disposal problem for mills not integrated with kraft mills. Because of the growing stringency of stream pollution laws, waste liquor disposal must be carefully studied and a practical solution developed in each case. This solution must satisfy the stream pollution authorities.

A survey of semichemical pulp mills indicates that the process design is by no means as standardized as are the usual pulping processes. Wide differences exist in process design between mills.

Wood Preparation

For corrugating board pulp the wood is often cooked without removing the bark. However, the low yield from the bark, the extremely large amount of dirt obtained, the lowered board quality, and the problem of wet spots caused by particles of bark holding the sheet off the driers have impelled most mills to install barking equipment.

The best method of bark removal is peeling in the woods but in many cases labor is not available for this operation. The advantages of purchasing peeled wood are: (1) cleaner wood than that barked by other means, (2) no investment in, or maintenance of, barking equipment, (3) less decay than in unbarked piled wood, (4) less storage space required than for unbarked wood, (5) no bark disposal problem. Total removal of bark from some hardwood species is very difficult although progress has been made in this problem. Poisoning is under extensive study as a bark-loosening method. The conventional methods, barking drums and hydraulic barkers, are often used. Their capacity is much lower than on coniferous woods.

Aspen wood chips as easily as the conifers but the denser hardwoods require a heavy chipper whose knives are maintained in good condition. An eight or ten-knife chipper equipped with a card breaker is best. The chips must be uniform and a length of $^1/_2$ to $^5/_8$ inch appears to be most desirable. The chips may or may not be screened but it is preferable to screen them. The sawdust contains much dirt, and the oversize chips contribute raw wood to the finished pulp and are apt to cause plugging in fluid refiner feed systems.

Digesters

Globe rotary or stationary vertical digesters are used by most mills. The trend, when these digesters are used, seems to be toward vertical digesters for mills larger than 60 tons per 24 hours and rotary digesters for smaller tonnages. However, this rule is only general; one large bleached semichemical pulp mill using globe rotary digesters is expected to eventually produce 200 tons per 24 hours. On the other hand, another semichemical pulp mill producing about 50 tons per 24 hours uses a vertical digester. Those who favor the globe rotary digester claim for it the following advantages over vertical digesters:

1. More uniform impregnation and cooking.
2. Shorter cooking time.
3. Higher chemical concentration through using a smaller liquor ratio, resulting in a lower volume of waste liquor. This is advantageous in liquor disposal.
4. Steam saving.

Others claim that the vertical digester equipped with an outside liquor circulating system will perform better.

Table III. Strengths of Semichemical Pulps Compared with Bleached Softwood Sulphite Pulps

Pulps	*Brightness, %*	*Strength property[a]*			*Test sheet density, %*
		Bursting, %	*Tearing, %*	*Folding, %*	
Commercial bleached softwood sulphite pulp[b]	85	100	100	100	100
Aspen semichemical pulps:					
Unbleached	48	90	100	30	80
Semibleached calcium hypochlorite (one stage)	75	90	90	50	90
Semibleached sodium hypochlorite (one stage)	72	100	100	75	90
Fully bleached (three stages[c])	84	115	125	75	90
Eastern hardwood[d] mixture semichemical pulps:					
Unbleached	49	65	125	10	65
Semibleached calcium hypochlorite (one stage)	76	65	110	10	75
Semibleached sodium peroxide (one stage)	73	75	125	10	70
Fully bleached (three stages[c])	85	110	105	75	85

[a] Comparisons at 350 ml. Canadian Standard.
[b] Basis of comparison.
[c] Chlorination, alkaline extraction, calcium hypochlorite.
[d] Beech, birch, maple.
Source: U. S. Forest Products Laboratory.

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Continuous pulping systems are used in an increasing number of mills with over 70 Chemi-Pulper systems reported to be in operation. A new development in the field is the Messing-Durkee pulper. These systems produce board grade pulp with the exception of one Chemi-Pulper system under construction which will produce bleachable semi-chemical pulp. Cooking is conducted at higher temperatures and pressures than in batch digesters, and the cooking time is shortened. Either neutral sulphite or sulphate or caustic soda cooking liquor may be used. The following advantages over a batch digester system are claimed by one manufacturer of continuous pulping systems based on a 300-ton per 24-hour mill:

1. Steam saving: approximately 1000 pounds per ton of pulp.
2. Power saving: approximately 3 hp. per ton of pulp.
3. Labor saving: approximately 50%.
4. Building saving: approximately 180,000 cubic feet.

Digesters-to-Refiners System

Globe Rotary Digester Systems. The cooked chips are dumped into a leach caster, a drain pit, or a circular bin equipped with a bin discharger. In one mill making bleached pulp the cooked chips drop into a dump tank in which they are kept in hot liquor at 180°F. From the leach caster, drain pit, or circular bin the drained chips are conveyed to the refiners by various mechanical conveying systems such as flat belt, drag link, or spiral screw conveyors and bucket elevators. When the chips are stored in hot liquor they are pumped to a drainer feeding a conveyor which in turn feeds the refiners.

Vertical Digester Systems. The chips are usually blown to a blow tank. In one mill, the chips are blown to a blow pit converted to a leach caster which feeds a mechanical conveying system to the refiners. Often, the digesters and the blow tanks are sulphite or sulphate digesters converted to this service. From the blow tank (or, in the case of the globe rotary digester system in which the chips are kept in hot liquor, from the dump tank), the chips are carried to the refiners by any of several systems. In one system, the chips are pumped at 10% consistency to a regulating box which feeds the proper volume to each refiner. The mixture of chips and liquor is easily handled by an open runner centrifugal pump. The pumping consistency can be high because most of the liquor in the mixture of chips and liquor is free. In another system, the chips are pumped at low consistency to a drainer feeding a mechanical conveyor which, in turn, feeds the refiners. A return line to the blow tank is provided for excess pumpage in most fluid feeding systems and a return conveyor for excess drained chips in "dry" feeding systems.

When the chips are drained before feeding to the refiner, that is, using a "dry" feeding system, this system will consist of: (1) a main conveyor carrying the cooked chips to the refiner; (2) at each refiner, a variable speed feeder; (3) a return conveyor for excess chips. An excess of chips is necessary to insure that the last refiner is uniformly loaded. Possibly, the only advantage of "dry" feeding systems is that magnetic tramp iron removal equipment is more easily applied than in fluid feed systems. The loss of heat in the chips with the usual "dry" feeding system is a marked disadvantage.

Continuous Digester Systems. The cooked material is discharged, through an Asplund defibrator or through a special valve, to a cyclone. The product varies from a mixture of fibers and coarse shives to coarse shives and broken chips depending on whether or not the Asplund defibrator is used. The discharged fiber may be reduced to low consistency and pumped to the refiners or it may be carried at high consistency by a mechanical conveyor. In one new mill using continuous digesters the fiber will be handled at high consistency throughout the system including final storage. No pumps will be used except in the washing system. The advantages claimed for such a system are:

1. A saving in capital cost due to the elimination of chests, pumps, and pipelines.
2. Ease of operation of the entire system from a central point will result in low labor costs.

Whatever the system, it is of the highest importance that the feed to the refiners be uniform. To produce uniform pulp, a uniform feed must be maintained.

Refiners

The word "refining" has so many meanings that a more accurate description for this operation is "pulping." This may be defined as the operation in which the chips and coarse shives are reduced to fibers. This operation is invariably performed in disk refiners. Whatever the pulping process, the refining stage is the heart of the process and its efficiency determines the quality of the finished pulp.

Three types of disk refiners are in use: the single rotating disk refiner in which feeding, fluid or "dry," is accomplished through the stationary head. Also used, with fluid feed only is the single rotating disk refiner in which feeding is accomplished through a hollow shaft carrying the stationary adjustable head. A jordan prebreaker is required ahead of this type of refiner. The third type is the double rotating disk unit.

Pulping is usually accomplished from chip to fiber in one stage but several large mills use two-stage pulping with washing between stages. This system design is considered to have the following advantages:

1. Two-stage refining is especially desirable when the pulp is washed on vacuum washers since the pulp from the first stage has a high freeness.
2. Greater refining system flexibility. This is desirable in order to compensate for variations in the quality of the cooked chips and to thus produce a uniform pulp of unvarying quality.
3. Pulp strength development can be carried to the point where little additional refining is required ahead of the paper or board machine. This, too, is advantageous in the production of uniform pulp since it allows central control of pulping and stock preparation in one system.
4. Some operators feel that less damage to the fibers occurs in a two-stage system since the reduction in each stage is less drastic.
5. Quality protection is afforded by the secondary refiners against incomplete shive reduction by an improperly operating primary refiner.

Washing

The pulp may not be washed, or it may be washed on a decker, or in vacuum or pressure washers, or in diffusers. Washing may take place between stages in a two-stage refining system or after refining has been completed in either a one or two-stage system. Deckers are confined to low tonnage systems usually where the pulp is used unbleached. Screens are normally located ahead of the washers.

Some mills using leach casters, drain the black liquor from the chips and then cover the chips with water to partially wash them, thereby reducing the corrosive effect of the black liquor on subsequent process equipment. If the water is not maintained at high temperature the chips will cool, resulting in increased refining power requirements and lower pulp quality.

The pulp should be washed. If not, severe corrosion of the paper or board mill equipment, especially wires, may be experienced when using neutral sulphite pulp. Also, when the pulp is not washed, it is common to operate with an open white water system. This in effect, is washing at very low efficiency. However, good slime control is required with closed white water systems.

Screening

Corrugating board pulp is not usually screened. Unbleached pulp for high grade products as specialty boards or newsprint is usually screened in rotary screens. Bleachable grade pulp is screened in either flat or rotary screens.

The foregoing data are composite from many mills and

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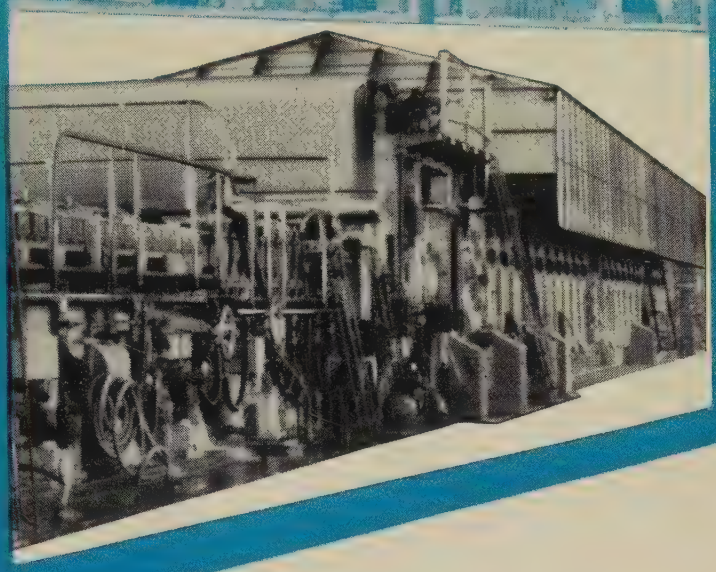

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almost any combination of these elements may be found in operation. An attempt will now be made to set up preferable semichemical pulping system designs for vertical, rotary, and continuous digesters.

DIGESTERS

The selection of the type of digester determines in great measure the entire pulp mill process design. Many factors must be considered in selecting the type of digester for an installation. For the batch production of pulp to be used unbleached the trend seems to be toward globe rotary digesters for production of less than 60 tons per 24 hours and toward vertical digesters with blow tank for larger productions. For unbleached pulp production in increments of 100 tons, the continuous digester must be considered. For the production of bleachable pulp there are, at present, no guides to digester selection. Both globe rotary and vertical digesters are used for large and small tonnages. The advantages claimed for globe rotary digesters, if substantiated, are important considerations when bleachable pulp production is planned. The continuous digester is being applied, in one instance, for bleachable pulp production.

Vertical Digester System

Using vertical digesters, a blow tank is preferable to a blow pit or leach caster for the following reasons:

1. The heat in the chips and liquor is retained. This results in power savings in refining and in improved pulp quality.
2. The chips can be pumped to the refiners rather than mechanically conveyed. A fluid feed system is more convenient, is as easily controlled, and requires less maintenance than mechanical conveyors.
3. Leach casters feed nonuniformly to the conveying system. This characteristic must be compensated for by carrying a large volume of chips on the main conveyor so that no refiner feeder will run empty between surges.

Using a pump system, the chips at 9 to 10% moisture-free consistency, are pumped from the blow tank to a regulating box which delivers the desired volume to each refiner and returns the excess to the blow tank.

The usual refining system is designed for one-stage operation. The refiners are operated in parallel and the chips are reduced to fiber in one pass. In two-stage operation, the chips are pulped in the first stage at a lower power input than for single-stage refining. The partially pulped fiber is washed after which it is pumped at 4 to 6% consistency to the second-stage refiners. Here, pulping is completed and the pulp strength developed to the desired degree. The pulp is fed through valve-regulated pipe lines connected directly to the second-stage refiners. A return line to the washed pulp chest is useful in controlling the total throughput of the second-stage refiners.

The pulp after first-stage refining may drop to a chest where it is diluted sufficiently to permit pumping to the washers or, the refiner may discharge to a header which feeds the washers directly. In the latter case, a sufficient amount of dilution water is added at the refiner discharge to sluice the pulp into the washers.

Washing is usually done on vacuum washers. The number of stages and size will depend on the production and other factors.

If the pulp is screened, rotary screens are satisfactory for both unbleached and bleachable pulp on the basis of their performance in various mills.

Summing up, the preferable system using vertical digesters is, we suggest, to blow the digesters to a blow tank. A blow tank pump with a return line feeds a regulating box at 9 to 10% consistency. The regulating box divides the flow among the refiners. Ahead of each refiner is a drainer. After refining, the pulp is washed, and screened if desired.

Globe Rotary Digester System

If a "dry" feeding system is used, a circular bin with continuous discharger or a V-shaped pit is preferable to a leach caster for receiving the cooked chips. From the bin or pit the chips are conveyed to the refiner through any of various types of mechanical conveyors including drag link, flat belt, and spiral screw conveyors. The best type is that having the fewest small parts which can come loose and be carried into the refiners. The spiral screw conveyor answers this requirement. An excess of chips must be carried to the refiners to insure a uniform feed to the last refiner. From the main conveyor, each refiner is fed by a small variable speed screw conveyor which carries the proper amount of chips at a uniform rate. This is the preferable system, we suggest, for "dry" feeding from rotary digesters.

It is possible to use a pumped fluid feed to the refiner with this type of digester and to obtain the advantages of better pulping through the conservation of the heat in the chips and lower transport system maintenance requirements than for mechanical conveyors. With this system the cooked chips are discharged into a dump tank below the digester. This tank is similar to the lower half of a blow tank and serves the same purpose insofar as the storage of the chips in hot liquor is concerned. The tank has a diameter only a few inches larger than that of the digester and it extends up to the digester floor level. This design reduces heat losses to a minimum. The chips in the dump tank are kept agitated in hot liquor. They are pumped at low consistency to a drainer discharging to a mechanical conveying system which feeds the refiners, or they may be pumped at 9 to 10% consistency to a regulating box which delivers the desired volume to a drainer ahead of each refiner and returns the excess to the dump tank.

The comments made on the refining system, on pulp washing, and on screening under vertical digester system apply equally to the globe rotary digester system.

Summing up, the preferable system using rotary digesters is predicated on two feeding systems: The preferable "dry" feeding system is, we suggest, to dump the digesters into a circular bin equipped with a continuous discharger or properly designed pit. The chips are conveyed to the refiner by a bucket elevator and screw conveyor, a chute returns the excess chips to the storage point. The preferable fluid feed system is, we suggest, that described above in which the cooked chips discharge into a dump tank where they are kept in hot liquor. The chips, at 9 to 10% moisture-free consistency are pumped to a regulating box which feeds the proper volume to a drainer ahead of each refiner. Between the "dry" and fluid feeding systems, the preference lies with the fluid feeding system for the reasons listed under vertical digester system.

After refining the pulp is washed, and screened if desired.

Continuous Digester System

The latest continuous digester system design is one in which the fiber is discharged from the digester at about 24% moisture-free consistency and is kept at high consistency throughout the process. The very coarse fiber discharged from the digester through the cyclone (an Asplund defibrator is not used) is conveyed to the refiners by a large screw conveyor. Feeding each refiner from the main conveyor is a variable speed small screw conveyor of special design. In the refining stage there will be very little dilution; the object being to refine at the highest possible consistency. A small storage bin is provided in the cyclone and also after the refiners. This is a highly specialized design. It promises economy in capital cost, in labor and operating costs, together with central control of the operations. Most continuous systems in use today use a less elaborate system in which the fiber from the cyclone is either conveyed directly to the refiners at 6 to 8% consistency or stored in a chest from which it is pumped to the refiners either directly or through a drainer.

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Washing is usually done on vacuum washers although in the system described, pressure washers will be used. The number of stages and size will depend on the production and other factors.

MATERIALS OF CONSTRUCTION

The word "neutral" in the neutral sulphite semichemical process has been responsible for the assumption that the process is noncorrosive to common materials of construction. Operating experience has proved that the process liquors, especially hot black liquor, are very corrosive. All process equipment materials in contact with hot liquor should be specified with this in mind. The problem is especially troublesome at points where a combination of corrosion and abrasion occurs. Such points are found in mechanical conveyors, pumps, refiners, etc. Types 304 and 316 stainless steel are satisfactorily resistant in our experience.

TRAMP METAL PRODUCTION

It is highly important to provide sufficient and effective tramp material protection ahead of the refiners. This will take the shape of magnetic equipment and, in the case of fluid feeding systems, settling points. The latter remove both magnetic and nonmagnetic tramp material. Tramp material can be an expensive and exasperating operating problem if it is not anticipated in the construction and design of the pulping system.

GENERAL

Semichemical pulp will sour much more quickly than fully cooked pulp. This characteristic should not be overlooked in the system design.

It is not easy to lap semichemical pulp on a wet machine and the production per machine will be low.

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Semichemical Pulps—Strength-Sheet Density Studies

DANIEL O. ADAMS and JAMES L. TENNANT, JR.

In the past decade the use of semichemical pulp as a component for flooring and roofing felts has become widespread (*1–8*). The pulping units generally consist of Asplund Defibrators preceded by B-K reaction chambers, used both with and without relatively low chemical treatment. The present study was initiated to compare pulps of varying yields for strength development with beating. The work was concerned primarily with possible application of these pulps in saturating felts.

Chips from Bird & Son, Inc., Phillipsdale, R. I., felt mill were sent to The Institute of Paper Chemistry for processing through a laboratory Asplund-type defibrator. Species analysis of the chips is shown in Table I. Bark was not removed.

The laboratory defibrator, although mechanically different from commercial models, was designed for pilot studies on pulps comparable to those produced in commercial units.

Daniel O. Adams, Chief Chemist, and James L. Tennant, Jr., Chemical Engineer, Research Division, Bird & Son, Inc., East Walpole, Mass.

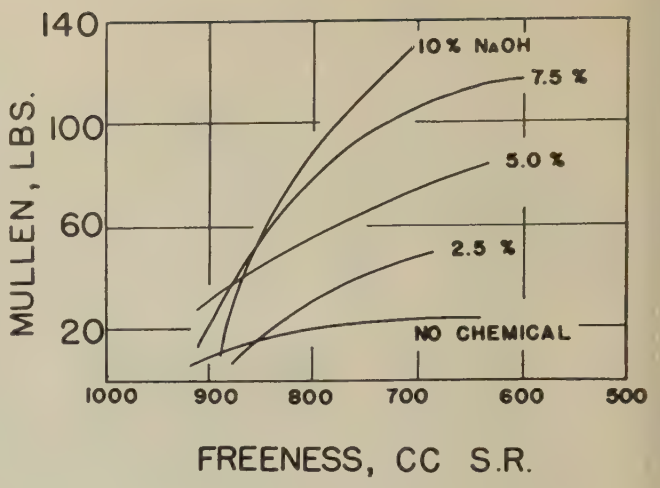

Fig. 1

Comparison of results obtained with handsheets made from laboratory pulp and pulp produced in a commercial unit showed that valid conclusions could be drawn. The laboratory pulps showed slightly higher strength properties, but trends were duplicated completely in mill studies.

Table I. Species Analysis

Oak	58.0%
Poplar, cottonwood, aspen, willow	6.5%
Maple	6.3%
Beech	4.1%
Basswood	4.2%
Birch	3.2%
Hickory, butternut, walnut	1.0%
Ash	0.6%
Unidentified	1.7%
Pine	0.9%
Bark	13.5%

PREPARATION OF PULPS

Chemical charges were diluted to a volume of 50 ml. and sprayed onto the chips as they were tumbled in a rotating cylinder. The chips were then placed in the preheater of the defibrator, processed after the preheating period, and yields determined. Yields for various kraft and soda treatments are shown in Table II. In all of the runs preheating time was 6 minutes at 140 p.s.i. The pulps were dewatered, treated with a preservative, and shipped to Bird & Son for beater studies.

PREPARATION OF HANDSHEETS

The pulps were beaten in a Valley beater using 5500 grams on the bed plate arm. Since the primary interest was in roofing and flooring felts, handsheets were made at a basis weight of 40 pounds per 480 square feet. Thus, although

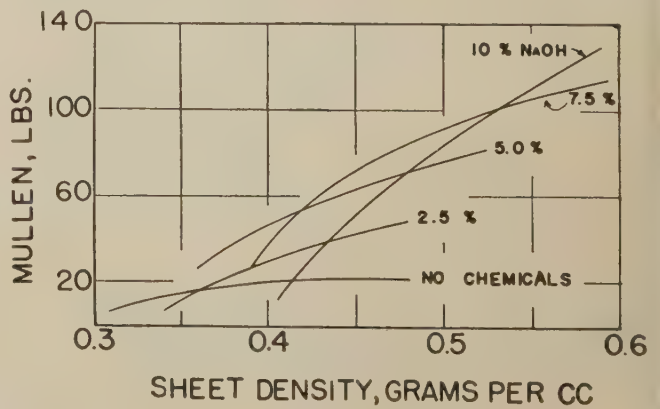

Fig. 2

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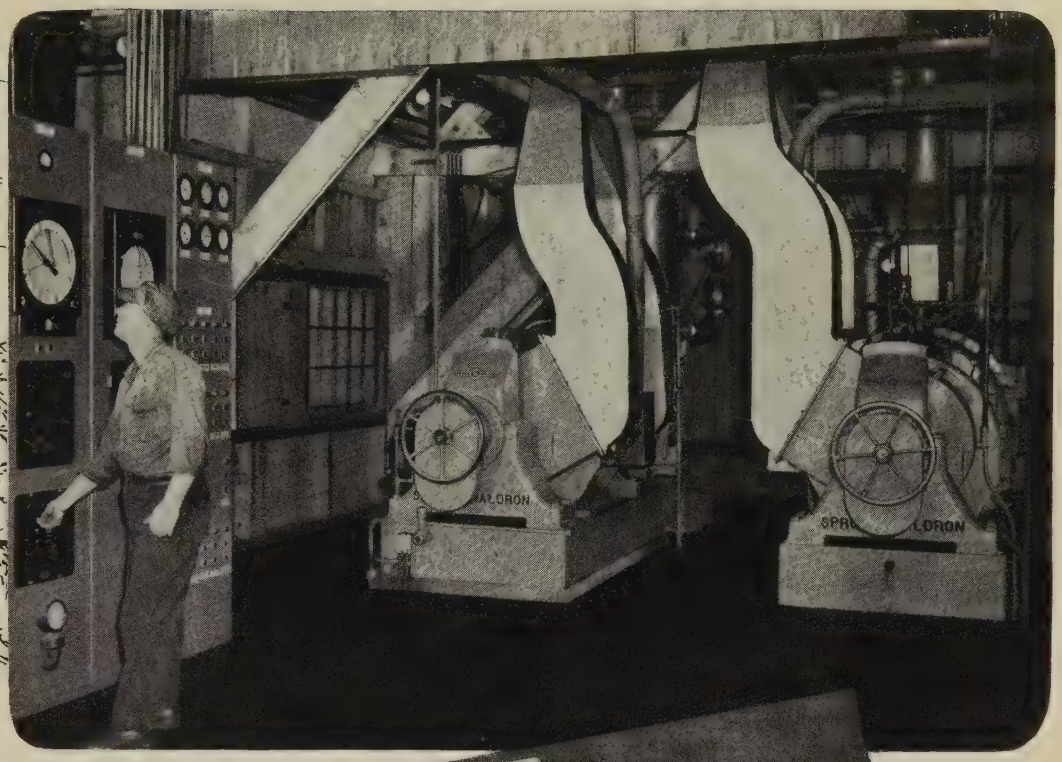

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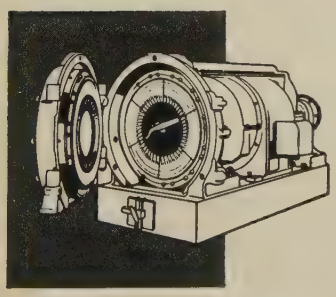

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239

TAPPI Standard T 200 m-45 was followed in part, the complete beater charge was dumped at each beating interval, to make sufficient sheets for testing. The sheets were made using a Noble and Wood sheet machine, press, and drier. Weights

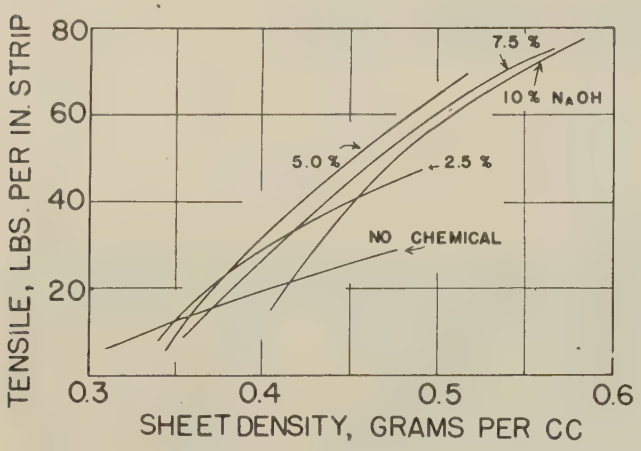

Fig. 3

on the press were varied to give a sheet density of approximately 0.4 gram per cc. when possible. Over most of the range of freeness studied it was impossible to obtain this

Table II. Yield Data

Chemical pretreatment	*Active alkali as NaOH, %*	*Sulphidity, %*	*Oven-dry yield, %*
None	..	..	84.8
Soda	2.5	..	82.2
Soda	5.0	..	77.5
Soda	7.5	..	68.8
Soda	10.0	..	68.0
Kraft	2.0	25	83.4
Kraft	3.5	25	82.3
Kraft	6.9	25	71.2
Kraft	12.9	25	63.0

density regardless of the number of weights used. All sheets were tested after conditioning at 50% R. H., 73°F.

SODA PULPS

The bursting strength of the soda pulps is plotted against freeness in Fig. 1. In this and all other figures the strength properties are for handsheets weighing 40 pounds per 480 square feet. These curves show increasing strength at a given freeness with increased delignification. This relationship has been suggested by Kehoe (*5*). Similar families of curves can be obtained by plotting tensile and tear versus freeness.

When these strength values are plotted against sheet den-

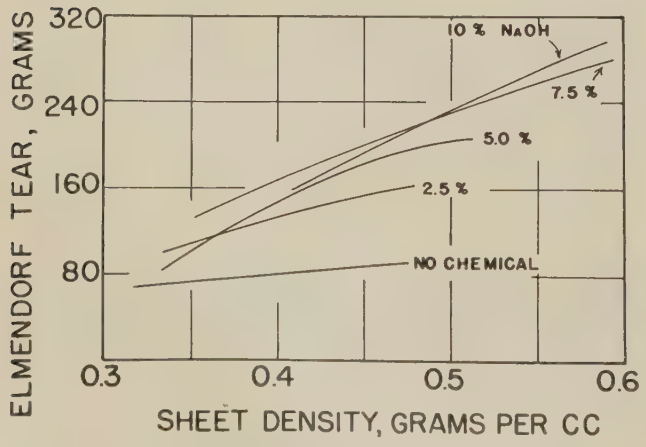

Fig. 4

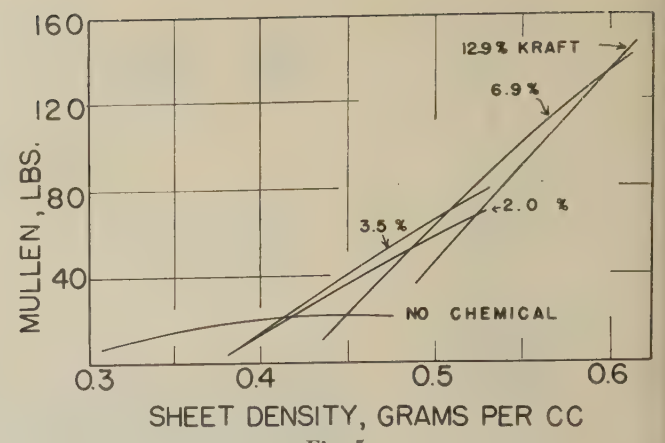

Fig. 5

sity (Fig. 2) the picture is more complex with the curves crossing each other. The plot of bursting strength versus freeness showed that at any given freeness increasing chemicals increased strength. The strengths of the unbeaten pulps are uniformly low. The densities of the unbeaten pulp sheet increase with increasing chemical. These densities are the minimum sheet densities obtainable from these pulps. With beating, both sheet density and sheet strength increase. The slope of the strength versus density curve is generally greater as the cooking chemical is increased. Thus there is a definite density range within which 5% NaOH gives maximum strength. In another range 2.5% NaOH gives maximum strength. The amount of cooking chemical to give the maximum strength pulp is probably a continuous function of sheet density.

This same relationship is apparent when tensile and tear strengths are plotted against sheet density (see Figs. 3 and 4).

KRAFT PULPS

Plots of bursting strength, tensile and tear versus freeness for the kraft pulps show increasing strength with increased delignification at a given freeness. These curves are similar in shape and position to those shown in Fig. 1.

Bursting strength, tensile, and tear of pulps prepared using kraft liquor are plotted against sheet density in Figs. 5, 6, and 7. These curves show the same relationship to each other as did the soda pulp curves. The kraft sheets, however, fall in a higher density range than the soda pulps.

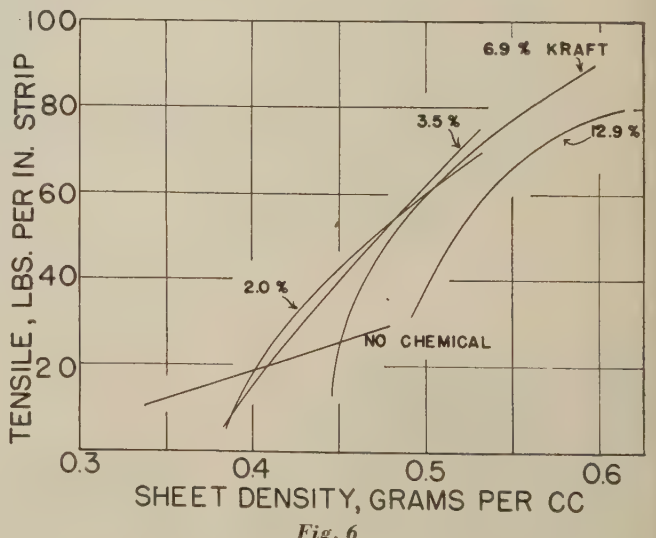

Fig. 6

Again at any given sheet density there is a maximum amount of chemical that can be used to gain maximum strength. At a given density the amount of active alkali needed for the

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kraft pulp of maximum strength is lower than for the corresponding soda pulp. In the range of low sheet densities greater bursting strength and tensile are obtained using soda rather than kraft liquor.

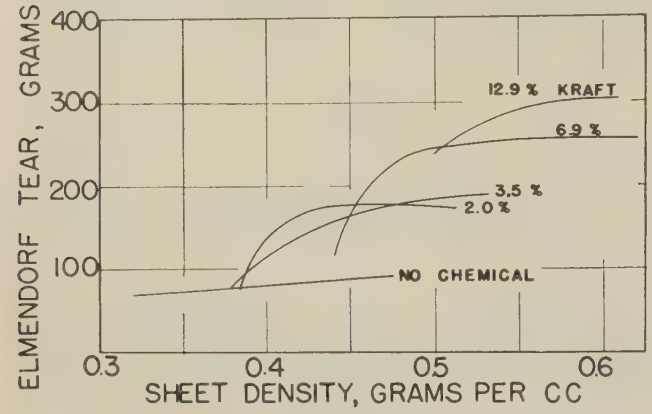

Fig. 7

For example, at 0.4 grams per cc. sheet density, treatment with 5% NaOH gave sheets with the highest burst (46 pounds) of the treatment investigated. However, at 0.53 gram per cc., 3.5% kraft yielded sheets with approximately the same bursting strength (82 pounds) as the 5% NaOH treatment.

SUMMARY

Strength properties of four soda and four kraft semichemical pulps have been compared. At any given sheet density there was a particular quantity of chemical which gave maximum strength. More or less chemical used in cooking resulted in weaker pulps at the given sheet density.

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Semichemical Corrugating Medium and the Paper Machine

W. W. MARTENY

By semichemical pulp reference is made to that produced by mechanically defibering hardwood chips that have been softened by the action of sulphite or neutral sulphite liquor and steam.

The discussion will be limited to the operation of fourdrinier machines making corrugating medium.

W. W. Marteny, Technical Director, National Container Corp., Tomahawk, Wis.

Naturally, with a process as new as semichemical, many variations are found in the pulp mill. These variations are evident in the composition of liquor, the type of digesting equipment and the defibering equipment. The degree to which the pulp is defibered in the pulp mill also varies among the several mills. Consequently, it is possible only to make a few general observations, and hope that we shall learn from the resulting discussion.

This particular type of pulp shows certain peculiarities common to that produced from hard woods. When the pulp is treated in a laboratory beater the tearing resistance increases with beating time and passes through a maximum much as the bursting strength.

The pulp is brash and sensitive to mechanical action. Development of strength and the decrease in freeness are rapid. If the refining action is not carefully controlled a large quantity of fines are produced.

The degree to which the pulp is defibered, or refined, in the pulp mill varies considerably. Samples of washed stock with over 60% retained on a 10-mesh screen are common. In these cases considerable refining power is expended in the paper mill. At the other extreme, operations exist in which no power is expended in the paper mill ahead of the machine.

In view of these wide variations no discussion of refining in the paper mill can be attempted. It would appear that no clear distinction between refining and defibering can be made. However, rough calculations of known connected power and production indicate that somewhere between 30 and 40 hp.-days are required to prepare a ton of pulp for the paper machine.

The freeness of the stock ahead of the fan pump is generally maintained between 300 and 450 ml. Canadian Standard freeness. This uniformity is quite surprising when comparisons are made between several mills.

The fibrous furnish for the board may vary from 100% to 75% semichemical pulp. Other portions may consist of refined chemical pulp screenings or wastepaper. The usual reason for the addition of longer-fibered pulp is to obtain a greater degree of safety from wet end breaks; although frequently refined screenings are used in corrugating medium merely to dispose of them.

It is my opinion that any so-called "sweetening" is really a diluent which tends to result in decreased quality. As machines are improved, or as papermakers are forced to improve the quality of the product, the need for "sweetening" will probably not be recognized.

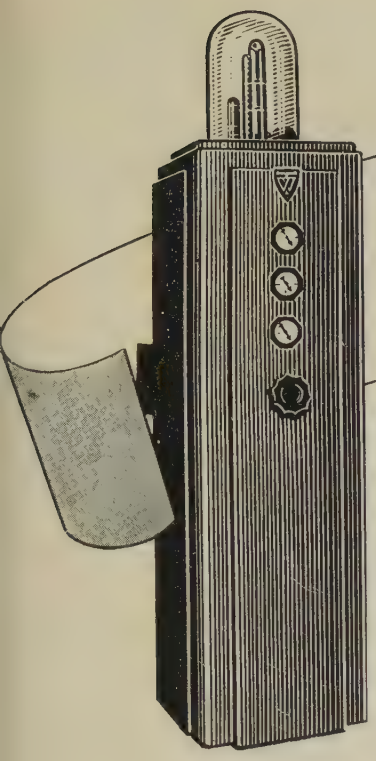
Generally, in making an unsized sheet, one would expect few chemicals in the furnish. Size and alum are not ordinarily used.

"Pitch" troubles are frequently of sufficient intensity to require the addition of special dispersing and anticoagulant agents. "Pitch" is used in the broad sense to refer to anything that deposits on the wire, felts, and rolls, Those familiar with acid sulphite pulps know of these difficulties.

Semichemical pulping processes are generally considered to result in conditions conducive to the growth of slime-forming organisms. The favorable media are believed to result from the partial hydrolysis of the polysaccharides. Apparently slime can be held within reasonable bounds by proper designs of the system.

It has been observed that a papermaker, who has to make semichemical corrugating medium on a machine that has been used on sulphate pulps, has a lot to forget and a lot to learn. This pulp requires entirely new techniques.

First of all, the freeness is low, and the water difficult to remove. If the papermaker tries to add water, or to reduce the headbox consistency to improve the formation of the sheet, he is in for trouble. Most operators have found that best results are obtained with a consistency in the headbox of approximately 1.0%. This appears to be necessary to get the water out of the sheet before the suction boxes. The



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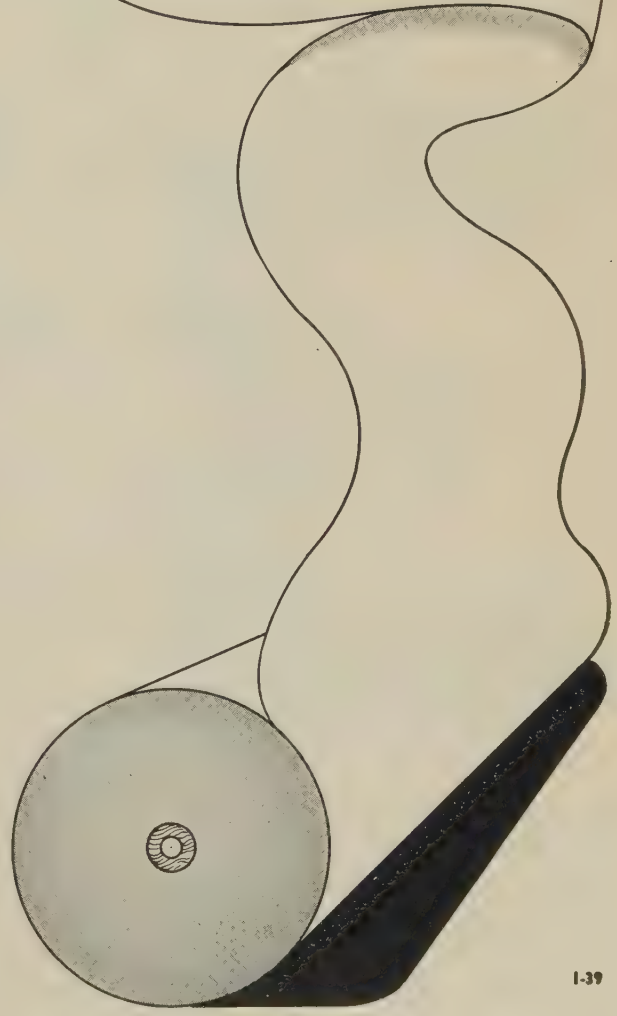

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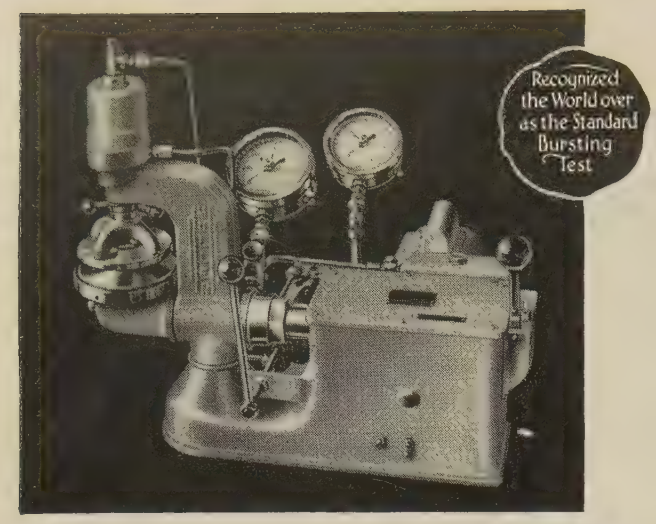

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actual consistency found best will depend upon many factors, such as the content of fines in the white water and the temperature of the stock.

The vacuum maintained on the suction, or flat boxes, is generally less than if the furnish is less slow.

Wire dandy rolls are used on some machines to help produce a more compact sheet, and to lay the surface fiber.

The use of lump crusher rolls at the suction couch is still a controversial subject. Generally, the tendency of the sheet to pick requires the use of a shower on the roll.

The vacuum used on the couch naturally depends upon many factors, such as the size of the vacuum pumps and the density of the sheet. It is used as a guide to the setting of the refining equipment.

Press sections are naturally operated to obtain the greatest removal of water possible. Usually the sheet does not crush too readily.

Drying rates are very likely to be lower than with sulphate pulp. Experience indicates that the drying rate is critically affected by the refining of the stock. The rate will usually be at a maximum for one particular degree of refining, and will decrease if the stock is refined more or less.

Again we find considerably different philosophies in regard to how the sheet should be calendered. One mill may use three nips, another none.

In summary we can compare the manufacture of corrugating medium from kraft and semichemical pulp as follows: semichemical pulp (1) requires higher consistency in the headbox, (2) requires less flat box suction, (3) dries with greater difficulty, (4) is more susceptible to tension in drying, (5) requires less calendering, and (6) has less strength in the wet web.

RECEIVED March 17, 1952. Presented at the 37th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 18–21, 1952.

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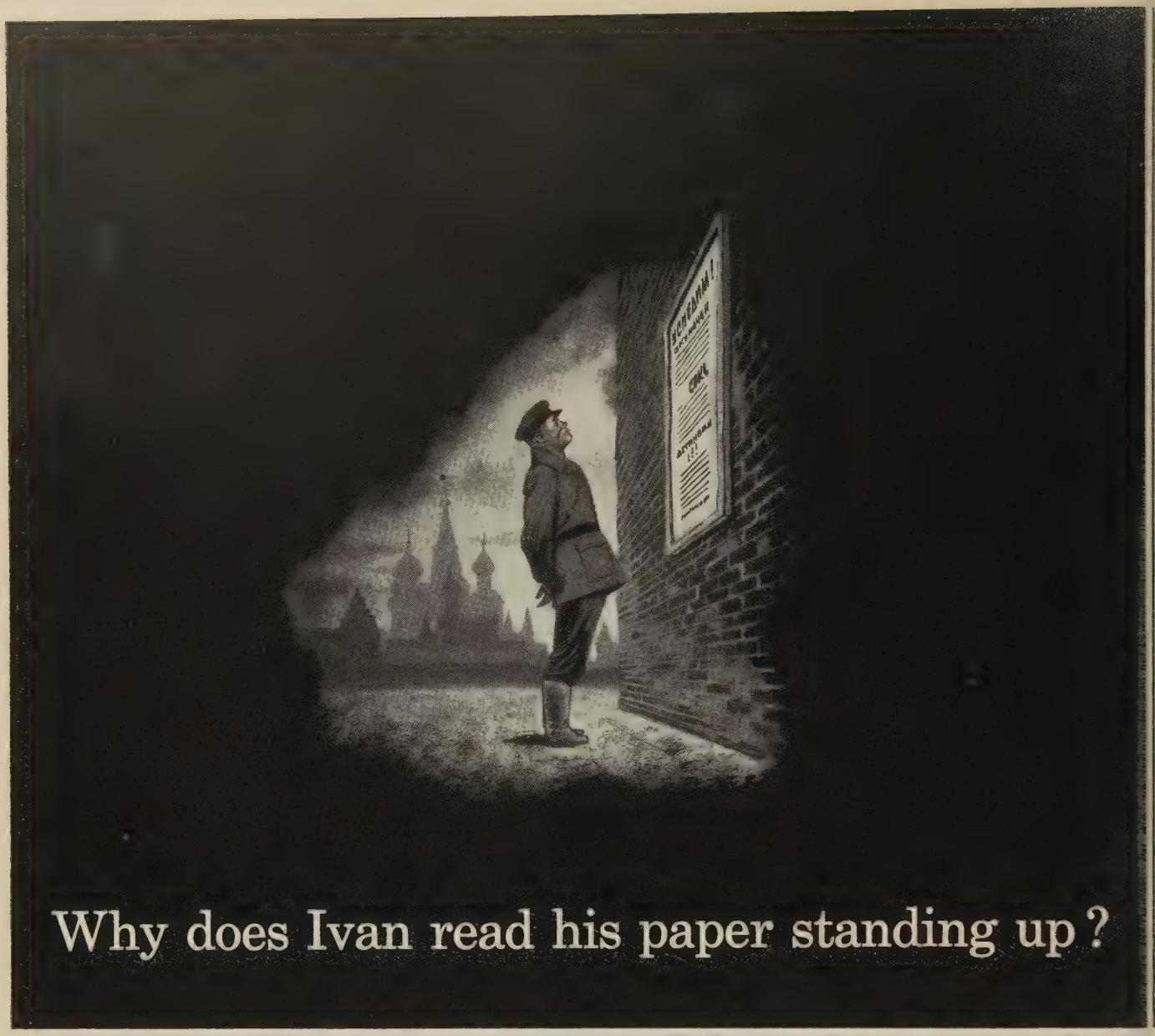

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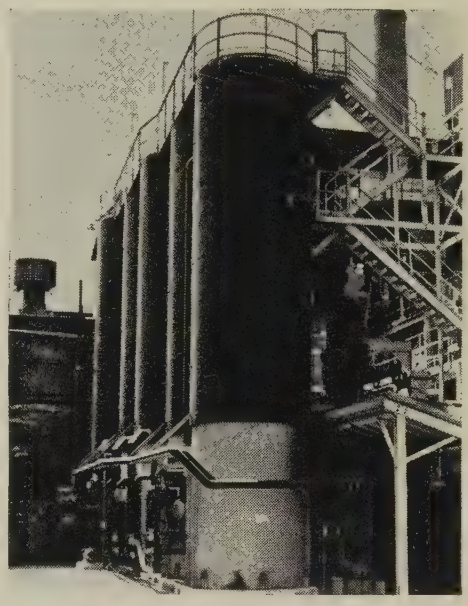

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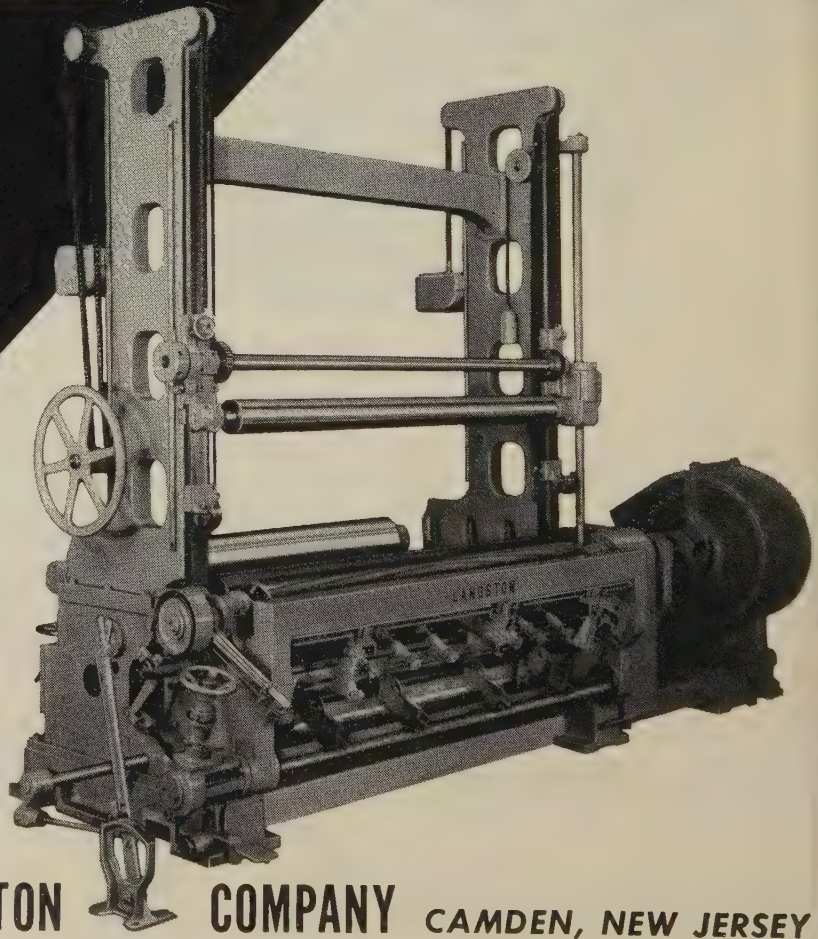

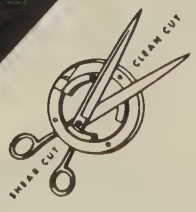

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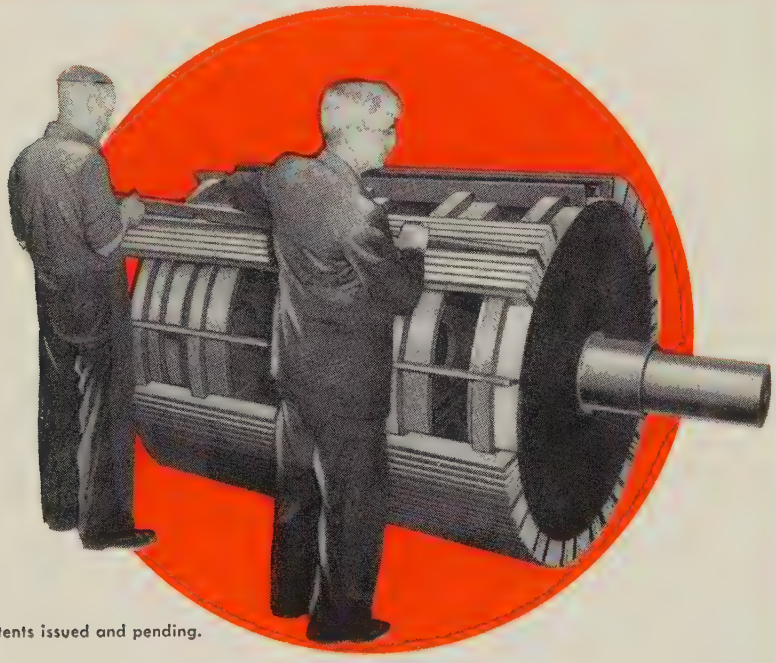

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The Simultaneous Measurement of Oxygen and Carbon Dioxide Permeabilities of Packaging Materials

A. H. LANDROCK and B. E. PROCTOR

A method for measuring oxygen and carbon dioxide permeabilities of sheet packaging materials, based on Dalton's law of partial pressures, is described. The test sheet is mounted between two chambers, the lower containing nitrogen and the upper swept with a mixture of oxygen and carbon dioxide. These gases permeate the sheet into the lower chamber at a rate dependent on their partial pressure differentials across the sheet. After small amounts of the gases have penetrated to the nitrogen side of the sheet, the gaseous mixture there is analyzed for oxygen and carbon dioxide. The results approximate actual packaging conditions, because the driving force across the sheet remains nearly constant and the pressures on both sides of the film are essentially atmospheric.

In the past decade several methods for measuring gas permeability have been in common use. The literature on this subject was reviewed in 1948 by West, Kunz, and Sears (*1*) in a paper in the bibliographic series of The Institute of Paper Chemistry and a year earlier by Paine (*2*) in England. Elder (*3*) has written an excellent discussion of the mechanism of gas permeability.

Most of the recent measurements have been made by the General Foods method as originally described by Shuman (*4*). This has been proposed as a standard test procedure by the Packaging Institute (*5*). According to this method, which employs a manometric apparatus, the test gas is present at 1 atm. on one side of the film; the space on the other side, being evacuated, is under very low pressure. The increase in pressure on the low-pressure side of the film as the test gas passes through the film is translated into terms of permeability units. Cartwright (*6*) described a modification of this manometric apparatus constructed entirely of glass and possessing increased sensitivity. Simril and Hershberger (*7*), in 1950, reported data obtained with an improved type of the General Foods apparatus.

Another method that has received widespread publicity is the isostatic sweep gas method of Davis (*8*, *9*). In this method, different gases, both at atmospheric pressure, are passed over opposite sides of a series of test sheets. The difference in partial pressure with respect to the test gas is 1 atm., and the test gas permeates the test sheets independently of the differences in total pressure. Any permeating test gas is picked up by the sweep gas and is determined by appropriate means after it has left the diffusion cell. The authors tried this method for studying the carbon dioxide permeability of packaging materials and found it satisfactory except that there was considerable difficulty in insuring against leakage and in finding a leak when it was known to exist. The apparatus is complex, especially when used to determine oxygen permeabilities where gravimetric absorption cannot be used.

In 1949, Zambito (*10*) of The Linde Air Products Co. reported the development of a method for determining oxygen permeability with the use of a sensitive tungsten filament for measuring low oxygen concentrations. This method, although undoubtedly giving useful results, is complex in use and relies upon a subjective measurement (the matching of a filament color) by the operator.

In 1944, Smith and Kleiber (*11*) described a method of measuring oxygen permeability based on changes in partial oxygen pressure. The film is mounted in sack form rather than as a flat sheet. Nitrogen is used on one side of the sheet and air on the other side. A gas analysis method is employed to measure the oxygen that permeates the sheet. The apparatus was built specifically for use with air.

In this same year, Todd (*12*) described a method somewhat similar to the General Foods method but utilizing a volumetric rather than a manometric principle for the measurement of permeability. A large chamber (evacuated) is used on one side of the test sheet and a small chamber held at atmospheric pressure on the other side. When the test gas passes through the sheet as a result of the partial pressure differential, a column of liquid in a horizontal tube moves in to replace the gas transmitted from the small chamber, thus providing a direct measurement of the permeability of the sheet to the test gas.

In 1946, Platenius (*13*) at Cornell University used a simple method for studying oxygen permeability. He drilled a hole in the bottom of a desiccator and through this hole provided two outlets with stopcocks. The test sheet was mounted somewhat crudely on the ground glass rim of the desiccator and held down with rubber bands and grease. The oxygen permeability across the film, when nitrogen was in the chamber and air outside, was measured at the end of the test period by means of an Orsat gas analysis apparatus. Only small amounts of oxygen were permitted to build up in the chamber. The method of Platenius suggested to the authors the method described in this paper.

DEVELOPMENT OF METHOD

For a long time the authors have been interested in measurements of the gas permeabilities of packaging films but have felt that no one method thus far developed possesses all or even most of the advantages that are desirable.

It is believed that the ideal method should meet the following requirements: It should:

A. H. Landrock, Member TAPPI; Technical Assistant in Packaging; B. E. Proctor, Professor of Food Technology and Head of the Department of Food Technology, Massachusetts Institute of Technology, Cambridge, Mass.

Contribution No. 121 from the Department of Food Technology, Massachusetts Institute of Technology, Cambridge, Mass.

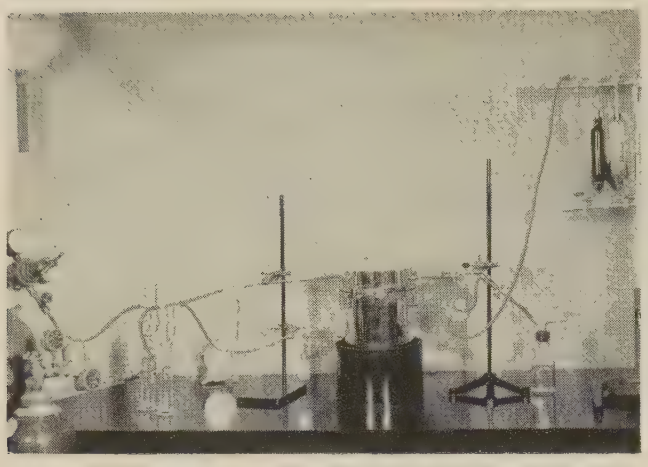

Fig. 1. Photograph of apparatus for simultaneous measurement of oxygen and carbon dioxide permeabilities of sheet packaging materials

(1) be simple in principle and technique,

(2) make use of standard laboratory equipment, insofar as possible,

(3) utilize a large area of test sample,

(4) provide a securely sealed-off sample sheet—if a clamping arrangement is used, it should be readily mounted and dismounted and should be tight—,

(5) provide for continuous inspection of the surface of the sample sheet,

(6) provide for the possible use of any gas or mixture of gases on either side of the test sheet,

(7) utilize the principle of Dalton's law of partial pressures in measurement of permeabilities to such gases as carbon dioxide and oxygen, to permit their simultaneous penetration of the sample sheet,

(8) provide for easy control of relative humidity on either side of the test sheet, and

(9) give accurate and reproducible results.

The method of Platenius, although capable of refinement, meets these requirements closely. However, any attempts on the part of the authors of this paper to sweep a gas or a mixture of gases through the desiccator cover, over the film, and back out again through the desiccator cover met with failure because of the difficulty of securing an adequate seal, even with a heavy lubricating grease. It was realized that some kind of pressure clamping arrangement had to be used. This eliminated the possibility of using readily available glass apparatus for the test cell.

A unit was finally designed that seemed to possess all the attributes of a good permeability cell. This unit, together with apparatus for control of humidity and pressure and for gas analysis, was used to measure the permeabilities of films to carbon dioxide and oxygen when these gases were allowed to permeate the film simultaneously. The principle of the method is based on Dalton's law of partial pressures, which states that in mixtures of gases each gas behaves independently of other gases present and that the total pressure is the sum of the partial pressures. Each gas will, therefore, permeate a sheet according to its partial pressure differential across the sheet. Smith and Kleiber (*11*) and Platenius (*13*) utilized this principle in their methods of measuring oxygen permeability.

The permeability cell was made from brass and later was chrome plated. The unit is cylindrical in shape and is divided into two chambers, the lower larger than the upper chamber. The upper chamber is attached to the lower by a unique hinge arrangement, which accommodates gaskets of varying thickness. Rubber gaskets $^3/_{16}$ inch thick are cemented to the $^3/_4$-inch rims of both chambers with rubber cement. Three fixed screw clamps are placed on the rim periphery so that clamping can be carried out with uniform pressure all around the rim, once the test film has been placed in position between the two chambers.

Windows, although not absolutely necessary, were considered helpful and so have been placed on opposite sides of the cell, in both chambers. These are sealed with Dek-Adhese[1] to prevent leakage.

To prevent undue distortion of the film during a run, heavy wire screening (3-mesh) is placed in position above and below the test sheet.

The entire cell, as finally devised, is illustrated in Figs. 1 and 2. This cell is the only complex part of the entire equipment but is simple in operation.

Glass humidity control towers are provided to supply humidity control in the upper and lower chambers. A back-pressure bottle partially filled with mineral oil prevents air from coming back into the apparatus and permits the gas that is swept through the upper chamber of the cell to pass through at a pressure only slightly greater than atmospheric pressure. Water is not used in this back-pressure bottle because of its volatility.

[1] This is a plastic cement, a product of the Gates Engineering Co., Wilmington, Del.

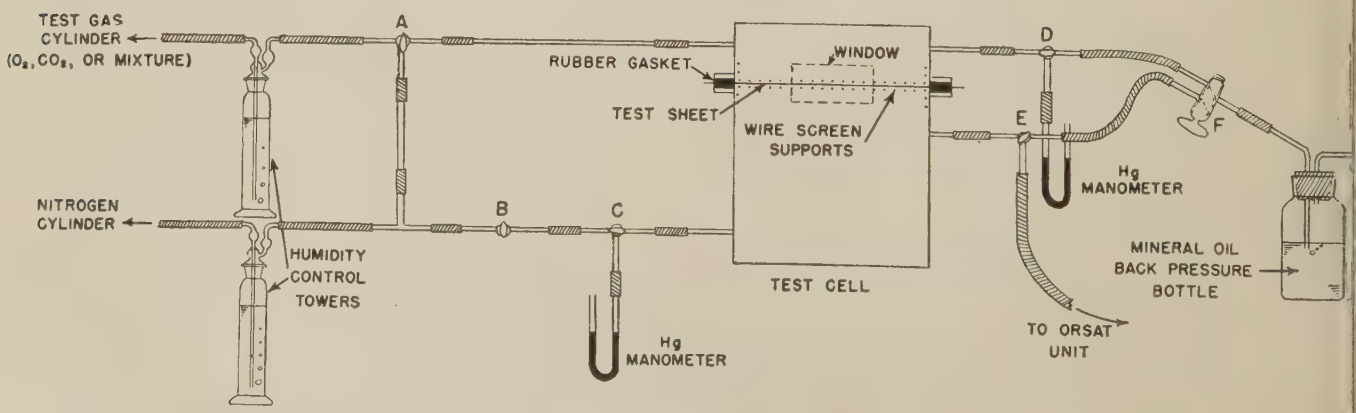

Fig. 2. Diagrammatic representation of apparatus

Open manometers are fitted to the upper and lower chambers. The lower manometer is indispensable for accurate work, but the upper manometer is probably not necessary.

For analysis of the gaseous mixture accumulated in the lower chamber of the cell, an Orsat gas-analysis apparatus (laboratory model) was used. The buret of this apparatus is in three sections, the lowest 6 ml. of which is graduated into 0.05-ml. units and the intermediate section into 0.10-ml. units.[2] This arrangement provides extreme accuracy in making measurements. Part of the gas-analysis apparatus may be seen in Fig. 1. It was found that the auto-bubbler type of absorption pipet was most suitable, even for carbon dioxide absorption with KOH. Needle valves are provided in the gas cylinders to insure a steady flow of gas at all times.

In food packaging, the permeabilities of packaging materials to oxygen and carbon dioxide are of vital importance. These two gases were therefore chosen for study, and a mixture of the two was made in the ratio of approximately 80% oxygen to 20% carbon dioxide. A search of the literature indicated that carbon dioxide permeabilities are usually about four times as high as oxygen permeabilities, and this ratio should permit the transfer of approximately equal amounts of the two gases through the test sheet per unit of time. The 80:20 mixture was prepared specially by a local gas manufacturer. Occasional checks showed no change in composition as the gas supply in the tanks became depleted.

OPERATION OF THE APPARATUS

The operation of the apparatus is as follows: if the test conditions specify 0% R. H., concentrated sulphuric acid is placed in the humidity control towers. The test sample is placed on the lower rubber gasket ring and clamped in place securely. Nitrogen is then passed through stopcocks B and C[3] into the lower chamber, stopcocks E and F being open all the way through to the back-pressure bottle. Stopcock A is closed off. The lower chamber is swept with nitrogen for about 2 hours, after which it should contain only a trace of oxygen.

It is essential to know the exact composition of the test gas in the lower chamber. This can be determined easily. With stopcock E closed off, nitrogen is forced into the cell under pressure until about $^1/_2$ inch of Hg pressure is built up. Stopcock B is then closed off so that the gas will remain in the cell. Slightly more than 100 ml. of sample is then drawn off into the gas buret, after the line has first been evacuated. This should leave close to 1 atm. of gas in the cell.

The test gas mixture is then passed across A, through the upper chamber, through D[3] and F, and into the back-pressure bottle. At first a high rate of flow is used, especially for films of high permeability. After 10 minutes or so of rapid sweeping, a rate of 60 bubbles per minute (at the humidity control tower) will provide more than ample replacement of the depleted test gas mixture, unless the sheet is extremely porous. The initial time of sweeping is noted and recorded.

The next step is to analyze the sample of gas held in the buret. If air only was in the lower chamber just before sweeping with nitrogen, it is not necessary to analyze the sample for its carbon dioxide content. "Oxsorbent" is used in the absorption of oxygen.

[2] The gas-measuring buret is the Burrell Laboratory Type 3A, Premier Model.

[3] Simple T-shaped connecting tubes *without* stopcocks can be used at C and D just as satisfactorily.

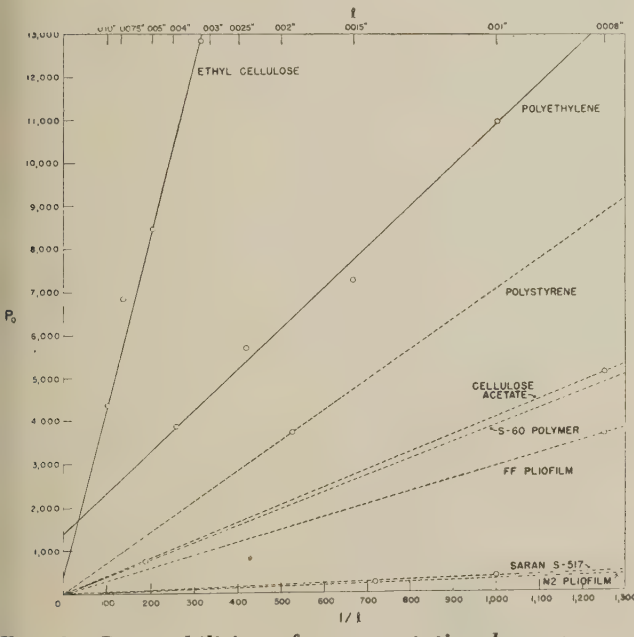

Fig. 3. Permeabilities of representative homogeneous films to oxygen as related to film thickness

l = film thickness in inches; P_0 = oxygen permeability expressed as cc./sq. m./24 hr./atm. The broken-line curves represent films studied at only one film thickness, and the indicated trends are, therefore, only estimates.

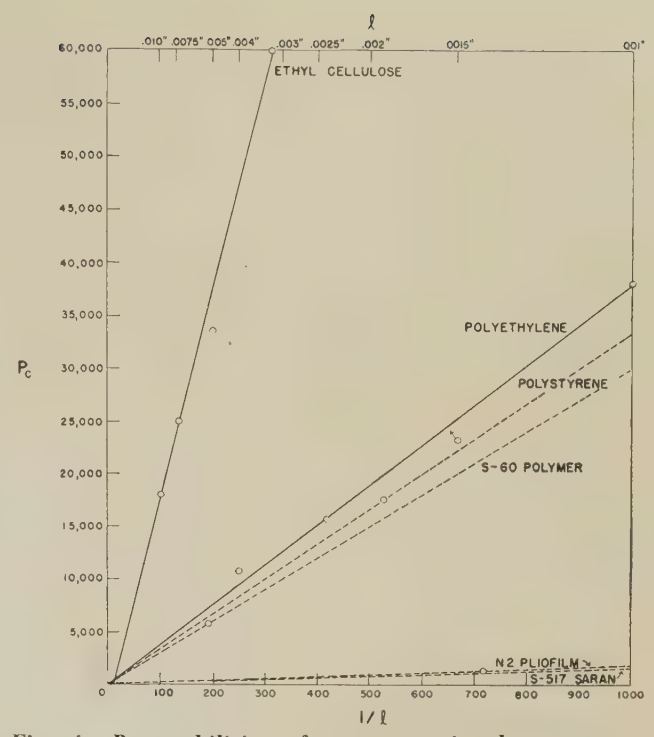

Fig. 4. Permeabilities of representative homogeneous films to carbon dioxide as related to film thickness

l = film thickness in inches; P_c = carbon dioxide permeability expressed as cc./sq. m./24 hr./atm. The broken-line curves represent films studied at only one film thickness, and the indicated trends are, therefore, only estimates.

Table I. Gas Permeabilities of Sheet Packaging Materials as Determined by Simultaneous Permeability Method[a]

(Av. Temp., ca. 25°C.)

Sheet	Gage, in.	R. H.	P_o[b]	S.P.$_o$[c]	P_c[b]	S.P.$_c$[c]	P_c: P_o[d]
Pliofilm N2	0.0014	0	*220*	0.053×10^{-6}	*1,400*	0.33×10^{-6}	6.3
Pliofilm FF	0.0008	0	3,700[e]	0.51×10^{-6e}	...	.....	...
Cellulose acetate (Lumarith P-912)	0.0008	0	5,100[e]	0.72×10^{-6}	...	.....	...
Saran S-517	0.0005	0	670[e]	0.059×10^{-6e}	4,800[f]	0.42×10^{-6f}	7.2
			860	0.076×10^{-6}	3,500	0.31×10^{-6}	4.1
Saran S-517	0.0010	0	390[e]	0.068×10^{-6e}	...	.....	...
Polyethylene	0.0010	0	14,500[e]	2.6×10^{-6e}	...	.....	...
			11,000	1.9×10^{-6}	38,000	6.7×10^{-6}	3.5
Polyethylene	0.0015	0	7,300	1.9×10^{-6}	23,000	6.2×10^{-6}	3.2
Polyethylene	0.0024	0	5,700	2.4×10^{-6}	16,000	6.6×10^{-6}	2.8
Polyethylene	0.0039	0	3,900	2.7×10^{-6}	11,000	7.4×10^{-6}	2.8
Polystyrene	0.0019	0	3,700[e]	1.2×10^{-6e}	15,000[f]	5.0×10^{-6f}	4.1
			3,700	1.2×10^{-6}	18,000	5.9×10^{-6}	4.9
Ethyl cellulose							
Mfgr. A	0.0032	0	13,000	7.2×10^{-6}	60,000	34×10^{-6}	4.6
Mfgr. A	0.0032	100	11,000	6.0×10^{-6}	32,000	18×10^{-6}	(2.9)
Mfgr. A	0.0050	0	*8,400*	7.4×10^{-6}	34,000	30×10^{-6}	4.0
Mfgr. A	0.0075	0	*6,800*	7.7×10^{-6}	25,000	33×10^{-6}	3.7
Mfgr. A	0.010	0	4,400	7.7×10^{-6}	18,000	32×10^{-6}	4.1
Mfgr. B	0.011	0	2,300	4.5×10^{-6}	13,000	25×10^{-6}	5.7
S-60 polymer	0.0053	0	750	0.70×10^{-6}	5,800	5.4×10^{-6}	7.7
Aluminum foil	0.0018	0	0	0	0	0	...
Foil-kraft laminate							
Foil	0.0019	0	*1,300*	.....	*605*	.....	...
Kraft	0.0026						
P-1 cellophane, 450 gage	0.0011	0	*1,100*	0.21×10^{-6}	*2,500*	0.48×10^{-6}	2.3
		100	*36,000*	6.8×10^{-6}	*180,000*	34×10^{-6}	(5.0)
MS-3 cellophane, 300 gage	0.0009	0	*961*	.....	*1,300*	.....	1.4
MSBO cellophane, 300 gage, wettable side down	0.0009	100	*3,200*	.....	*14,000*	.....	(4.4)
						Average =	4.25[d]

[a] Unless otherwise stated, test gas was mixture of ca. 80% O_2 and 20% CO_2.
[b] Expressed as cc./sq. m./24 hr./atm. Italicized values represent single determinations; all other values are averages of from 2 to 10 determinations.
[c] Expressed as cc./sq. cm./min./cm. thickness/atm.
[d] Figures in parentheses were not used in calculating the average ratio of P_c to P_o (4.25) because of high relative humidity or pore-type permeation.
[e] Test gas was 100% O_2.
[f] Test gas was 100% CO_2.

The initial pressure at the lower manometer is noted. At the end of the test period, the length of which is determined by the properties of the film or sheet, the new pressure is noted and another sample is drawn from the lower chamber for gas analysis. No more than $^1/_2$ inch of Hg pressure should be permitted to build up in the lower chamber, if possible.

It is suggested that, in general, sufficiently accurate end results will be obtained if each test gas is allowed to permeate the test sheet until its concentration in the lower chamber is increased about 1%. In the case of polyethylene of 0.0015-inch gage, this would require a test period of about $8^1/_2$ hours. Shorter periods can be used where convenient, however.

It has been stated that approximately equal amounts of carbon dioxide and oxygen should permeate the film under typical conditions. Under these conditions the apparatus is equally sensitive to both gases.

CALCULATIONS

The equation used in calculating the carbon dioxide permeability is as follows:

$$\frac{(24)(V)(C_f - C_i)}{(A)(h)\left[\frac{(C_t - C_i) + (C_t - C_f)}{2}\right]} = \frac{(48)(V)(C_f - C_i)}{(A)(h)(2C_t - C_i - C_f)} =$$

$$\frac{(48)(5855)(C_f - C_i)}{(0.0324)(h)(2C_t - C_i - C_f)} = \frac{(8{,}680{,}000)(C_f - C_i)}{(h)(2C_t - C_i - C_f)} = P_c$$

V = total gas volume in lower chamber, cc.
A = area of exposed test film, sq. m.
h = test time, hr.
C_t = per cent CO_2 coming from tank
C_i = per cent CO_2 initially in lower chamber
C_f = per cent CO_2 finally in lower chamber
P_c = permeability of test sheet to CO_2 expressed as cc. per sq. m. per 24 hr. per atm.

For calculation of oxygen permeability, O is substituted for C in the above equation. The figures for V and A in the equation apply to the apparatus as built by the authors.

It will be seen that the equation is a straightforward algebraic expression reduced to simple terms. One fundamental assumption is made, namely, that the average driving force across the sheet is equal to the arithmetic mean of the initial and final driving forces. This is not strictly true, but for slight build-ups of test gas in the lower chamber the assumption is a reasonable one.

When the relative humidity is above 0% on either side of the test sheet, it is necessary to correct for the volume occupied by water vapor. This is done by multiplying the numerator by $(100 - W_U)/100$ and the denominator by $(100 - W_L)/100$, where W_U equals the volume per cent of water vapor in the upper chamber and W_L the volume per cent of water vapor in the lower chamber. At 25°C. the pressure of water

Table II. Reproducibility of Data for Polystyrene (0.0019 Inch) at 0% R. H. and 25 ± 3°C.

(Sweep Gas Mixture)

Carbon dioxide permeabilities[a]	
17,500	15,350
18,690	16,030
23,050	17,200
28,000	15,700
15,080	9,320

Mean ($\bar{X}$) = 17,600
Standard deviation (σ) = 5010
Coefficient of variation (V) = $(\sigma \times 100)/\bar{X}$ = 28.5%

[a] Expressed as cc./sq. m./24 hr./atm.

vapor at saturation is 23.76 mm. Hg and the volume per cent, or W, is then (23.76 × % R. H.)/760 or 3.13% at 100% R. H. Obviously the correction factors for water vapor cancel out when the relative humidity is the same in both chambers.

If it is desired to correct to standard conditions of temperature and pressure (0°C. and 1 atm.), the permeability value must be multiplied by $273/(273 + t)$. At 25°C. this correction would reduce the permeability value by about 9%. In the results reported in this paper no correction of the values to standard temperature and pressure has been made, however, partly because of the lack of constancy of temperature when the observations were made (22 to 28°C.) and partly because correcting to 0°C. is somewhat misleading in gas permeability studies. The casual user of gas permeability data is apt to draw the conclusion that the measurements were made at 0°C. if the results are corrected to this temperature. This is especially serious because at 0°C. the permeability rate would be only about three-sixteenths of the rate at 25°C.

The specific permeability of a test sheet to either oxygen or carbon dioxide is calculated according to the formula suggested by Davis (*8, 9*), namely:

$$S.P. = P \times \text{caliper in inches} \times 0.176 \times 10^{-6}$$

where $S.P.$ equals specific permeability expressed as cc. per sq. cm. per min. per cm. thickness per atm., and P equals permeation rate expressed as cc. per sq. m. per 24 hr. per atm.

EVALUATION OF RESULTS OBTAINED

The permeabilities of a wide variety of sheets, some of them of several thicknesses, were studied by this method, and the results are summarized in Table I.

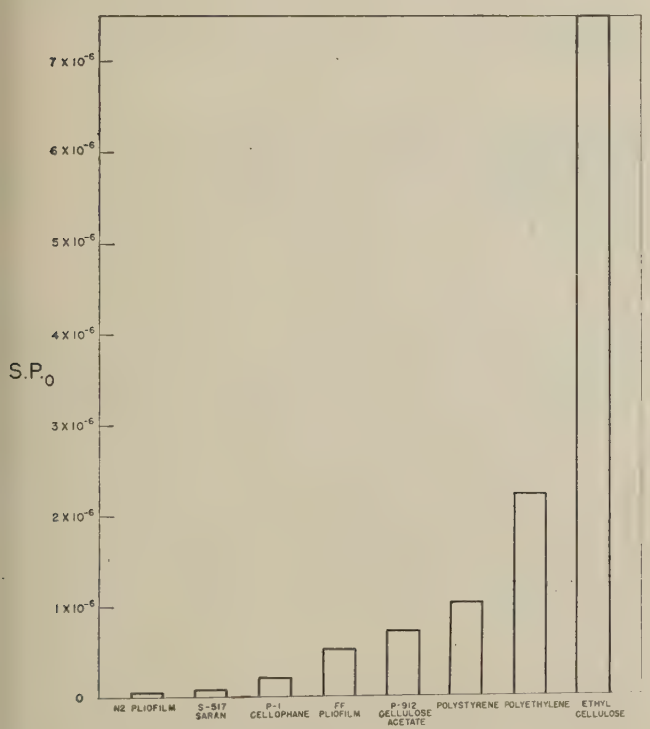

Fig. 5. Specific permeabilities of representative homogeneous films to oxygen

$S.P._0$ = specific permeability to oxygen expressed as cc./sq. cm./min./cm. thickness/atm.

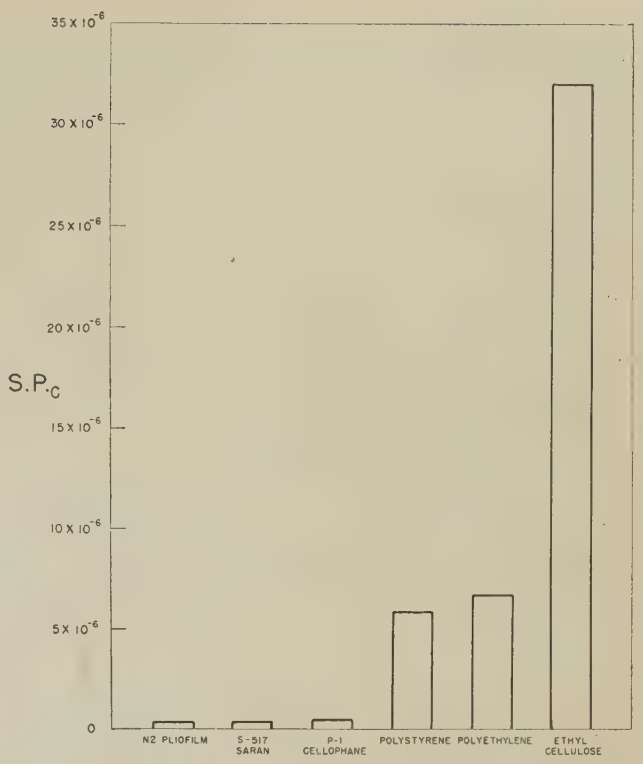

Fig. 6. Specific permeabilities of representative homogeneous films to carbon dioxide

$S.P._C$ = specific permeability to carbon dioxide expressed as cc./sq. cm./min./cm. thickness/atm.

All the values reported except those in italics represent averages of from two to ten determinations. Because of inherent inaccuracies in the method, the results are recorded to only two significant figures.

Because of the lack of temperature control, the average room temperature during the time of any given test ranged between 22 and 28°C., which should give a variation in permeability units of about 30% above and below that at a mean of 25°C. This assumption is based on data given by Amerongen (*18*), which, when plotted, indicate that a rise in temperature of 1°C. will usually be accompanied by a 10% change in the permeability.

To ascertain the degree of reproducibility of results obtained by this method, a statistical analysis was made of the data for polystyrene of 0.0019-inch gage at 0% R. H. It will be seen from Table II that the coefficient of variation was 28.5%, which corresponds well with the value of 30% mentioned above.

The values obtained for permeabilities at 0% R. H. have been plotted in Figs. 3 and 4 with reference to the reciprocals of film thicknesses. The curve for any given sheet should be and is a straight line. In both these figures single points have been plotted for a number of films where sheets of a single gage only were available. Broken lines have been drawn connecting these single points with the origin. These lines will give some idea of the probable trend of permeabilities at a relative humidity of 0%, over a wide range of film thicknesses.

The permeability of ethyl cellulose was high compared with the permeabilities of other films. Its permeability appeared to be much more affected by changes in film thickness than was the case with a film such as polyethylene.

The N2 Pliofilm showed low permeabilities, which were of the same order of magnitude as those of Saran S-517. This particular grade of Pliofilm is reported by the manufacturer to be one of the less permeable grades. The differences in the specific permeabilities of the two grades of Pliofilm, N2 and FF, show the necessity for recording the exact types used in permeability studies.

Figures 5 and 6 give some idea of the range of specific permeabilities of the films tested. In the comparison of one homogeneous film with another, the specific permeabilities are considerably more important than the permeabilities themselves, for calculations of specific permeabilities reduce the measurements to the basis of films of a common thickness.

In the last column of Table I are recorded the ratios of carbon dioxide permeability to oxygen permeability (P_c to P_o). The high ratio for S-60 polymer is of considerable interest compared with the low ratio for polyethylene. Apparently the ratio for the S-60 polymer is about three times as high as that for polyethylene.

In two instances permeabilities were studied with respect to the effects of different relative humidities. Plain cellophane (P-1) showed a tremendous increase in permeability with increase in relative humidity, whereas ethyl cellulose showed a less marked decrease, especially with respect to carbon dioxide permeability. Todd (*12*) also has reported a decrease in permeabilities of test sheets at high relative humidities.

A fair evaluation of our method by comparison of our results with those obtained by other methods (*7–16*) is difficult. This difficulty can be largely attributed to the paucity of published data and also to the lack of completeness in the descriptions given of film types.

It is believed that the results obtained by the new method are as valid as those obtained by other commonly used methods. On the whole, agreement with previous work is good. The new method offers many useful advantages over other methods and should, therefore, be of considerable use in the food packaging industry.

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The Use of Statistical Methods in Research

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The purpose of this paper is an attempt to present as briefly and in as nontechnical a manner as possible, some of the statistical methods available to the research worker in the pulp and paper industry and to demonstrate some of the advantages which may be gained through the use of a few of these techniques.

The background literature on statistical methods used in research work appears highly technical and involved to anyone not trained in statistics. Many useful methods are consequently neglected simply because the first impression the average person receives when he opens a book on statistical methods is one of great complexity, strangely formidable symbols, and an involved technical language.

Just as the highly technical phases of Shewhart's work in quality control have been reduced to more easily understood and readily applied methods for average or routine control work, so the fundamental work of Fisher and others involved in the development of statistical techniques in research has been simplified and made more comprehensible by such authors as Brownlee. By applying these more simplified techniques and accepting their derivation with a reasonable amount of faith, powerful tools are available for evaluating experimental data, planning experimental work, and reducing both technical and personal bias in research.

It has been said that the average or mean is the most familiar statistical value known—it seems as if everything can be reduced to an average if necessary. The average is easy to compute and, although familiarity may breed contempt, is held almost in reverence by many individuals. As long as the average results are

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he same, no one worries—that is no one but the customer who finds both extremes of the range in his material at the same time. Statistical methods are available for measuring the dispersion of values about the mean and, as each of these techniques is applied, more is known about the population from which the mean was derived.

For example, the use of the high and low values in the distribution in conjunction with the mean gives an indication of the extremes and sets the range. The use of the mean or average deviation (the sum of the deviations of the individuals from the mean divided by the number of individuals $\Sigma(d)/N$) gives a further and more complete measure of the dispersion about the average since it takes all the items, not just the extremes, into consideration. The standard deviation or the root mean square deviation ($\sqrt{\Sigma(d^2)/N}$) is the quadratic mean of the deviations from the arithmetic mean. The standard deviation is one of the basic concepts in statistical work and is related to the normal curve and probability functions. The value of the mean can be further enhanced by calculating the coefficient of variation [$V = (\sigma/X)\ 0.100$] which is the ratio of the standard deviation to the mean expressed as a per cent. Since this is a relative value, it may be used in the comparison of the dispersion about one mean with that about another of different numerical magnitude.

Further use of statistical techniques permits the estimation of not only the relative variability but also the accuracy and confidence limits of a mean or average. Thus it is possible to determine the ± limits within which the mean should fall 95, 99, or 99.9% of the time. With some additional calculations it is possible to compare two averages and to determine within what probability they are derived from the same or from different populations. The Student (t) test is an invaluable aid to the research worker in helping him to avoid unwarranted conclusions from the data available or by preventing involuntary bias from affecting the interpretation of experimental results.

As the value of the techniques mentioned above becomes apparent to the technical worker, there usually develops a desire to look further afield for new methods of more adequately expressing the results of his work or for extracting more useful information from the data he has laboriously accumulated. The field of correlation presents many potential methods to help make research data more valuable. It is through correlation that relationships between variables can be reduced to equations or lines of regression. The relationships can frequently be used in this form for predicting the value of a dependent variable from one or more independent variables. The use of Spearman's rank correlation method ($\rho = 1 - [6\Sigma(D^2)/N(N^2 - 1)]$) where D is equal to the difference in rank, permits the approximation of the coefficient of correlation and so may give an indication of the value of further pursuing the more tedious linear, nonlinear, or multiple correlation methods.

The techniques of variance analysis permit the breakdown of variability in multistage processes in order to assess each component with its share of the variation in the final product. This technique permits the concentration of work on phases of a process or experiment which will produce the greatest improvement in the end result. Variance analysis is the key to the evaluation of factorially designed experiments which permit the simultaneous investigation of several variables and the estimation of their effects on product qualities. This brings the discussion—somewhat hastily—to the subject of experimental designs. The need for planning experimental work to secure data in a form suitable for analysis is a fairly obvious deduction from the foregoing discussion.

There are several reasons for designing experiments statistically. Such designs are built up in a logical manner and take into account all the factors which are to be studied and recognize those which are to be controlled. It may also be necessary to adjust the design for those factors which it is impossible or impractical to control. This is usually accomplished through randomization of the tests in order to assure the impartial assignment of treatment arrangements to eliminate or modify personal or systematic bias. This permits an independent and unbiased evaluation of the errors to which the system is exposed as well as permitting the estimation of all treatment effects without confusion from uncontrolled variables.

There are numerous designs reported in the literature for various types of experimental requirements. Due to time limitation only one type will be discussed in this paper.

Where two or more variables or different factors are being examined at the same time, as is often desirable in pulping or papermaking research, factorial designs are among the most satisfactory arrangements to obtain the greatest value from the least effort. In these designs, all the variants of each factor are applied in association with all the variants of each other factor. The advantages of factorial designs are apparent when it is realized that they permit the estimation of the effects of all factors to be made from the whole experiment, they indicate where the factors interact, and that any conclusion reached about one factor has a wider basis than if its effect were examined with the other factors held constant.

Experience has shown that a three-factor experiment yields highly gratifying results for a relatively small amount of calculation on the part of the investigator. In such experiments the effects of three variables may be investigated at two levels in eight experiments. Twelve experiments permit the study of three levels of one variable and 18 experiments the evaluation of three levels of two of the factors and two levels of the third.

Such experimental designs may well be used in the investigation of bleaching techniques, pulping experiments, coating studies, or any of the other multivariant problems facing the pulp and paper technician. It should be pointed out that these methods have been proved successful in experimental work ranging from bench size laboratory studies, through pilot plant or semicommercial research experiments to full-scale commercial operations. It might pay to briefly list some possible uses of these designs in the field of research in which this group may be interested.

For example, in the field of bleaching studies, the effects of temperature, type of bleaching agent, use of buffering agents, different pH levels, and consistency

may be investigated in relation to the effects on pulp brightness, dirt and shive removal, degradation measurements, or refining characteristics of the bleached stock for the same or for different pulps.

In the case of pulping research, such variables as chip size, pretreatment techniques, chip packing, cooking temperatures and cycles, chemical concentrations or liquor concentrations, composition of the liquors, may be studied in relation to yield, screenings, bleachability, pulp degradation, refining characteristics, or chemical composition of the final pulp. Again it should be remembered that the estimate of the effects of the major variables is accompanied by estimation of significant interaction which may be valuable guides in planning future steps in the research program.

In papermaking the effects of different sizing agents, both in the beaters and in the tub, may be evaluated in conjunction with changes in furnish, filler content, or operating conditions. The significance of changes in fiber furnishes on sheet characteristics might be studied at different machine speeds under different operating conditions or with varying after-treatments.

Coating research offers a wide field for the use of factorial designs in the evaluation of different base stocks, pigments, binders, plasticizers, and a wide range of other factors which influence such sheet characteristics as bonding strength, printability, surface, color, and general strength of the coated paper. Here again, the estimation of not only the major effects but also of interactions between variables may throw light on important factors influencing the development of special sheet characteristics.

With this brief introduction to some of the possible applications of factorial designs in various aspects of pulp and paper manufacture, it might be well to illustrate the method with an example. While the data presented in this evaluation are hypothetical, the basis for setting up the experiment is from actual experience, and the results are within reasonable agreement with what might actually have been found if such an experiment had been conducted.

In this case, the problem under consideration is a study of the effects of several variables in the development of a duplicator paper for a liquid process machine. The reflectances of colored blocks at the 25th impression are to be used as an indication of copy strength and the following information would be highly desirable in designing a sheet to meet the requirements of the duplicating process.

1. Will a change in the kind of starch used in tub sizing the sheet influence the copy strength?
2. Does the concentration of the starch as it is applied to the paper affect the copy strength?
3. While it is known that increased fluid flow in the duplicator will affect copy strength, is there a difference in this effect with different starches or with different starch concentrations?
4. Is the effect of increasing the concentration the same for different starches?

This statement of the problem permits the selection of the factors which are to be investigated and permits the planning of the experimental work to obtain the answers to the questions raised. By using a three-factor design in which two different starches will be applied to the paper at two different concentrations the basic material for the duplicating trials at two different fluid feeds will be obtained. It is perhaps unnecessary to point out that the usual precautions of adequate and careful sampling be observed in order to be sure that the stock selected is representative of the conditions under investigation.

After the paper has been made and sampled, the different sets of samples are run on a duplicator of the type for which the paper is being developed. Efforts should be made to standardize as many of the machine's operational characteristics as possible before making the test runs. Such factors as preliminary runs to insure even fluid flow, saturated wicks, and smooth operation can be standardized. In order to further eliminate the effects of machine variables, the test runs may be randomized and if duplicate tests are to be made for each set—the whole series can be so treated. On completion of the runs, the reflectances from the 25th impressions are obtained for each trial in the series. These results, along with a summary of the effects of the major variables and a summary of the tests for significance, are shown in Table I.

Table I. Study of the Effects of Tub Sizing Starch, Starch Concentration, and Duplicator Fluid Setting on Copy Strength

Reflectance of Printed Blocks at 25th Impression, G.E. Brightness Meter

Fluid settings Starch	Concentration	F_1	F_2
S_1	C_1	25.0	35.0
	C_2	22.0	30.0
S_2	C_1	19.0	25.0
	C_2	20.0	27.0

F_1—High fluid setting F_2—Low fluid setting
S_1—Starch A S_2—Starch B
C_1—High concentration C_2—Low concentration

Summary of Results

	Effect of fluid Setting F_1	F_2	*Effect of Starch* S_1	S_2	*Effect of concentration* C_1	C_2
Av.	21.5	29.2	28.0	22.8	23.5	24.8

Interaction of starch—concentration

	C_1	C_2
S_1	30.0	26.0
S_2	22.0	24.0

Summary of Significance Tests

Differences caused by	*Variance ratio*	*Significance level*
Fluid	68.3	Greater than 0.01
Starch	27.5	Greater than 0.01
Concentration	...	Not significant
Interaction of:		
Fluid—starch	...	Not significant
Fluid—concentration	...	Not significant
Starch—concentration	7.0	Just under 0.05

In examining these data it is noted that the effect of increased fluid flow produces darker copies as was expected and had been noted in the statement of the problem. This effect is highly significant—approaching the 0.1% level. The difference in copy strength caused by the type of starch employed also reaches significant proportions at the 1.0% level—there being only one chance in a hundred that a difference this great would be caused by chance variation. Examination of the significance tests for interactions involving fluid differences shows that neither the fluid-starch nor the fluid-starch concentration interactions reach significant levels. There is, however, an ap-

parent interaction noted between the starch and the concentration which approaches the 5.0% level of significance usually accepted as denoting a real difference. In this case, lower concentrations of the first starch produced darker copies while higher concentrations of the second starch produced similar results.

In reviewing the statement of the problem in light of the experimental work and its evaluation, the following answers may be given to the questions originally asked.

1. A change in the kind of starch will produce a change in copy strength. Starch no. 2 yields darker copies at the 25th impression than starch no. 1 even when different fluid conditions and different concentrations of starch are employed.

2. The concentration alone does not significantly affect the over-all copy strength for these starches.

3. The relationships between the fluid and starch used and the fluid and the concentration of starch employed do not reach significance. However, the over-all effect of fluid flow is highly significant in respect to copy strength.

4. There are indications that the concentration effect is different for different starches. Consequently, since the level of significance is not very high, additional tests of this relationship should be carried out.

It is hoped that this hypothetical example has illustrated the method by which a factorial design might be applied to a papermaking problem. The arithmetic involved in the variance analysis has not been included but may be found in one of several reference works. Suffice it to say that the calculations are not burdensome.

In conclusion it should be stated that, while considerable emphasis has been placed on the three-factor experimental designs, these are but one of many techniques which may be used in research work. None of the methods described in this paper are beyond the comprehension of the average research worker and, when reduced to less formidable terms than those often found in the textbooks, become easily assimilated into the general techniques he has available for producing better and more valuable results from his labors.

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Acetolysis Products of Slash Pine Alpha-Cellulose Studied by Chromatographic Methods

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Cotton cellulose and filter paper have frequently been subjected to acetolysis but wood celluloses have seldom been studied by this reaction. In the work herein described, an alpha-cellulose prepared from slash pine (*Pinus caribaea*) was subjected to acetolysis and the resultant sugar acetates were fractionated by adsorption chromatography. The crystalline substances isolated from the fractions were α-cellotriose hendecaacetate, α-cellobiose octaacetate, β-cellobiose octaacetate, and α-D-glucopyranose pentaacetate. Studies of the mother liquors (by paper partition chromatography) indicated that a disaccharide of mannose may have been present in the α-cellotriose hendecaacetate fraction and that a disaccharide of glucose and mannose was almost certainly present in the α-cellobiose octaacetate fraction. These results would indicate that some of the mannose units in slash pine alpha-cellulose are chemically linked to glucose units as well as to other mannose units. Most of the mannose units in the acetolyzate were found to be in either the monosaccharide acetates or cellodextrin acetates fractions. Chromatographic studies of the acetolyzate of ivory nut mannan "A" indicated the presence of a mannose disaccharide acetate; no crystalline acetates of mannose or mannose oligosaccharide acetates were isolated. Studies of the material (from the alpha-cellulose) insoluble in cuprammonium hydroxide and cupriethylenediamine revealed the presence of glucose units only. Studies with sodium periodate and periodic acid indicated that the sugar units (both glucose and mannose) in the slash pine alpha-cellulose are substantially all linked through positions 1 and 4.

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Acetolysis is a particularly useful tool for structural studies on polysaccharides because the carbohydrate fragments produced indicate the original structure of the polymer. The applications of acetolysis to the study of cotton cellulose have been numerous and quite successful, but wood celluloses have seldom been investigated by this technique. The development of chromatographic methods (adsorption and paper partition) has greatly improved and facilitated the separation of constituents of acetolyzates. Excellent brief reviews of acetolysis studies on cellulose have been presented by Heuser (*1*) and Pigman and Goepp (*2*).

The original investigation of the acetolysis of cellulose was performed by Franchimont (*3*) in 1879. He treated Swedish filter paper with acetic anhydride and sulphuric acid and isolated a crystalline substance which was later identified by Skraup and König (*4*) as cellobiose octaacetate. Skraup and König recognized the significance of this material as being the "simplest polysaccharide from cellulose, as maltose is the simplest polysaccharide from starch."

Bertrand and Benoist (*5*) were the first to isolate what they believed to be a glucose trisaccharide from the acetolyzate of filter paper; Ost (*6*) later confirmed this belief by proof of the structure of cellotriose obtained from a cotton acetolyzate.

Dickey and Wolfrom (*7*) extended the series of glucose oligosaccharide acetates through the hexose by acetolysis of filter paper. The separation of the ace-

tates of this polymer homologous series was performed by adsorption chromatography, using methods previously developed for sugar acetates by McNeely Binkley, and Wolfrom (*8*) and by Georges, Bower, and Wolfrom (*9*). In connection with the use of adsorption chromatography, it should be mentioned that an excellent discussion of chromatography of sugars and related substances has been presented by Binkley and Wolfrom (*10*).

Wise and Russell (*11*) initiated the acetolysis studies of wood celluloses in 1923. They subjected the alpha-celluloses (or chemical pulps) of 10 common woods to acetolysis and in all cases isolated cellobiose octaacetate from the acetolyzates. Wise and Ratliff (*12*) isolated both α-cellobiose octaacetate and α-D-glucopyranose pentaacetate from the acetolyzed alpha-cellulose of slash pine. An interesting discovery in this work was that mannose units present as 10% of the original wood persisted not only in the alpha-cellulose but also in the cellodextrin acetates after acetolysis.

The purpose of the present investigation was to apply chromatographic methods in the study of the acetolysis products of slash pine (*Pinus caribaea*) alpha-cellulose in an effort to obtain data of structural importance.

PREPARATION OF THE ALPHA-CELLULOSE

Extracted slash pine wood meal was subjected to a chloriting treatment as outlined by Wise, Murphy, and D'Addieco (*13*), using four 1-hour extractions. The resultant holocellulose was given two successive extractions with 5 and 24%, respectively, potassium hydroxide under nitrogen.

The results of the analysis of the alpha-cellulose are presented in Table I.

Table I. Chemical Analysis of Alpha-Cellulose

Lignin, %	0.8
Ash, %	0.6
Mannan, %	10.4

Paper partition chromatography studies showed no uronic acid or arabinose and only the slightest traces of xylose in a hydrolyzate of the alpha-cellulose.

ACETOLYSIS OF ALPHA-CELLULOSE

A 20.0-gram (oven-dry basis) sample of the alpha-cellulose was introduced, with stirring, into the following acetolyzing medium:

Acetic anhydride	190 ml.
Glacial acetic acid	190 ml.
Sulphuric acid (sp. gr. 1.84)	19.05 ml.

The reaction was carried out with continuous stirring at 20°C. for 168 hours. The acetolyzate was recovered by pouring into ice water (fortified with sodium acetate to react with the sulphuric acid), neutralizing with sodium bicarbonate, and extraction with chloroform. The chloroform solution of the acetolyzate was concentrated on a steam bath, dried in a vacuum oven at 53°C., and dried to constant weight in a vacuum desiccator over calcium chloride and sodium hydroxide. The yield of acetolyzate was 38.8 grams. The acetolyzate was "stabilized" by filtration (in acetone solution) through a bed of Magnesol.*

* Magnesol is a synthetic, hydrated magnesium acid silicate manufactured by the Westvaco Chlorine Products Co., South Charleston, W. Va.

A portion of the acetolyzate was chromatographed (4.0 to 4.3-gram batches) on Magnesol-Celite (5 : 1 parts by weight) using 74 by 280-mm. columns of adsorbent and 7500-ml. portions of 100 : 1 (parts by volume) benzene-ethanol developer. The developed columns were extruded, streaked with aqueous alkaline permanganate, and dissected. The acetolyzate fractions were eluted with acetone, concentrated, dried, and weighed. A typical chromatographic pattern is shown in Fig. 1 and the yields of fractions are tabulated in Table II.

Table II. Fractional Yields of Acetolyzates

	Percentage of total acetolyzate adsorbed on column			
Fraction	First acetolysis	Second acetolysis	Third acetolysis	Over-all yield based on 1st acetolyzate, %
1	49.0	41.2	49.8	10.0
2	..	18.2	20.9	13.1
3	6.5	5.4	2.6	9.6
4	9.8	15.1	7.4	18.7
5	2.6	7.5	3.7	7.0
6	6.1	24.7 (?)	21.7 (?)	22.6 (?)

The yields of fraction 6 of the second and third acetolyses are considered dubious because the substances could not be thoroughly dried.

The cellodextrin acetates fraction (fraction 1) was subjected to a second acetolysis using identical reaction conditions on the basis of 1 part by weight of free cellodextrin being equivalent to 2 parts by weight of cellodextrin acetates. The chromatographic separations were repeated on this second acetolyzate and the cellodextrin acetates fraction of this was subjected to a third and final acetolysis. The chromatographic patterns for the second and third acetolyses were quite similar to that for the first (see Fig. 1). The yields of fractions for the second and third acetolyses are presented in Table II.

Crystalline Products

The crystalline products isolated from the acetolyzate fractions were α-cellotriose hendecaacetate, α-cellobiose octaacetate, β-cellobiose octaacetate, and α-D-glucopyranose pentaacetate. The basis for the identification of these substances was melting point, mixed melting point, and specific rotation as shown in Table III. In addition, hydrolyzates of all purified crystalline ma-

Table III. Identification of Crystalline Substances

Identified as	Fraction 2, α-Cellotriose hendeca-acetate	Fraction 4, α-Cellobiose octaacetate	Fraction 5, β-Cellobiose octaacetate	Fraction 6, α-D-Glucopyr-anose-penta-acetate
Melting point, °C.				
Found	220–221	228	202	113
Literature (*7*)	223	229	202 (*14*)	113
Mixed melting point, °C.	222	222	200[a]	.....
$[\alpha]_D^{20-25}$ (chloroform, c 4)				
Found	+20.9	+40.4	−14.7	+101.0
Literature (*7*)	+22.6	+41.0	−14.7	+101.6

[a] The β-cellobiose octaacetate for the mixed point determination was prepared by the sodium acetate-acetic anhydride method (*15*). After four recrystallizations from 95% ethanol, the β-cellobiose octaacetate was found to melt at 201°C. and have a specific rotation of $[\alpha]_D^{20-25} = -14.9°$ (chloroform, ca. 4).

terials showed the presence of only glucose when subjected to paper partition chromatography.

Fraction 3 failed to yield any crystalline substances even after several rechromatographic treatments. The identity of the material adsorbed in this region of the column remains unknown.

To the best of the author's knowledge, this is the first time α-cellotriose hendecaacetate has been isolated from the acetolyzate of a wood alpha-cellulose, the first time β-cellobiose octaacetate has been isolated from a cellulose acetolyzate, and the first time β-cellobiose octaacetate has been separated chromatographically from α-cellobiose octaacetate.

Mother Liquors

The mother liquors from all crystalline products were combined, dried, and chromatographed from a chloroform solution in a manner identical to that previously described. The chromatographic pattern was very similar to that shown in Fig. 1.

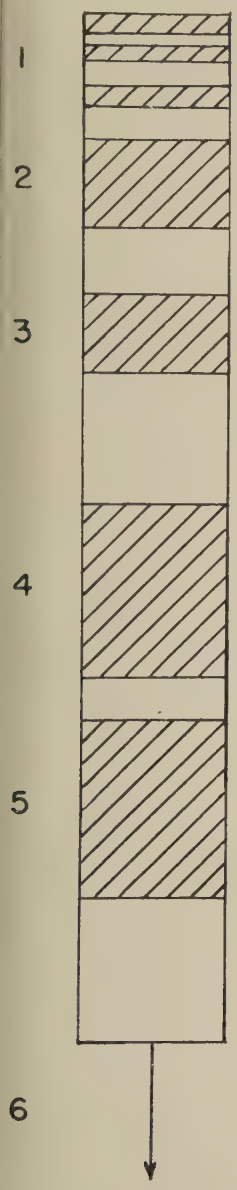

Fig. 1. A typical chromatographic pattern for an alpha-cellulose acetolyzate

Fractions 2, 4, and 5 yielded small amounts of α-cellotriose hendecaacetate, α-cellobiose octaacetate, and β-cellobiose octaacetate, respectively; fraction 6 was not investigated. Fractions 2 and 4 were deacetylated by sodium methylate as recommended by Zemplén (*16*). Portions of these deacetylated fractions were studied by paper partition chromatography and were found to contain cellobiose, glucose, and mannose, and one unknown material. The unknowns were detected on the paper chromatograms as spots intermediate in position between cellobiose and glucose.

The unknown spot for deacetylated fraction 2 corresponded in position exactly to a spot produced by a disaccharide of mannose from ivory nut mannan (to be described shortly); this material was not further investigated.

The unknown spot for deacetylated fraction 4 occupied a position on the paper chromatogram identical to glucosidomannose. Upon hydrolysis with formic acid, the material producing this spot was decomposed to glucose and mannose as shown by paper partition chromatography.

The possibility that a disaccharide (acetate) of mannose may have been present in fraction 2 and that a glucosidomannose acetate was probably present in fraction 4 is strengthened somewhat by evidence from adsorption chromatograms. Under identical conditions of development, fraction 2 and the mannose disaccharide acetate from ivory nut mannan were found in the same general region on the columns. Moreover, when α-cellobiose octaacetate and glucosidomannose octaacetate were mixed, they could not be separated under the conditions of adsorption chromatography used in this work.

In order to draw valid conclusions concerning the possible sugar unit linkages in the alpha-cellulose, it was necessary to show whether the disaccharides in question could have been formed as products of synthesis from monosaccharides (reversion) under the conditions of acetolysis employed. This was done by subjecting to acetolysis conditions a mixture of cellobiose, glucose, and mannose in approximately the same proportions as their acetates were present in a typical alpha-cellulose acetolyzate. In addition, a separate experiment was performed using mannose as the subject of acetolysis. Chromatographic studies (adsorption and paper partition) indicated that no glucosidomannose (or acetate) was formed from the free sugars cellobiose, glucose, and mannose under the conditions of acetolysis employed. However, studies on the mannose which had been subjected to acetolysis conditions revealed that a substance corresponding chromatographically to the disaccharide from ivory nut mannan acetolyzate was present.

The discovery of a mannose disaccharide (even though in very small amounts) present as a reversion product casts doubt upon the theory that the possible mannose disaccharide from a slash pine alpha-cellulose acetolyzate was a degradation product of a mannan chain. However, the discovery of no glucosidomannose as a reversion product strongly supports the hypothesis that a disaccharide (acetate) of glucose and mannose was present in the alpha-cellulose acetolyzate as a result of degradation. The important implication is that glucose and mannose units are almost certainly linked chemically in the alpha-cellulose of slash pine.

Distribution of Mannose Units in the Acetolyzate

Samples were withdrawn from all acetolyzates and acetolyzate fractions for study of the mannose unit concentrations. The samples were deacetylated, hydrolyzed, and subjected to paper partition chromatog-

Table IV. Distribution of Mannose Units

Part	*Total acetolyzate*	*Fraction 1*	*Fraction 6*
First acetolysis			
Glucose, %	86.5	87.4	81.9
Mannose, %	13.5	12.6	18.1
Second acetolysis			
Glucose, %	88.1	84.8	80.4
Mannose, %	11.9	15.2	19.6
Third acetolysis			
Glucose, %	83.8	83.8	78.8
Mannose, %	16.2	16.2	21.2

Only in one case (fraction 1, first acetolysis) did duplicate determinations differ by more than 1.6%.

raphy. Only in the total acetolyzates, fractions 1 and fractions 6, were mannose units found to be present in greater than trace amounts. This explains why so little mannose in any disaccharide form was found. The samples containing considerable amounts of mannose were studied by the technique of Hirst and Jones (*17*) for quantitative estimation of sugars using paper partition chromatography. The results of the analyses appear in Table IV.

Table IV shows that the mannose units tend to accumulate in the cellodextrin acetates and monosaccharide acetates fractions. This suggests that some of the mannose units in slash pine alpha-cellulose are of the same order of resistance to acetolysis as the glucan. However, it would also appear that the mannose-containing oligosaccharides are more susceptible to acetolytic cleavage than are the oligosaccharides of glucose.

COMPARATIVE ACETOLYSES OF COTTON, ALPHA-CELLULOSE, AND MANNAN

In view of the fact that alpha-cellulose is a polymeric material composed almost entirely of glucose and mannose units, it seemed particularly appropriate to compare alpha-cellulose by acetolysis with polymeric materials composed exclusively of glucose units (cotton linters) or almost exclusively of mannose units (ivory nut mannan).

The alpha-cellulose was found by quantitative paper partition chromatography to consist of approximately 88.5% glucose units and 11.5% mannose units. The glucose presumably was present as D-glucopyranose units linked β-1,4 glycosidically in a normal cellulose chain. The mannose presumably was present as D-mannopyranose units but its linkages were unknown with respect to adjoining sugar units and position of linkages.

The cotton linters were obtained from the Buckeye Cotton Oil Co. of Memphis, Tenn. The cotton linters had been purified by a dilute caustic cook, a chlorine bleach under acid conditions, a chlorine bleach under alkaline conditions, and a thorough water wash (*18*). Hydrolysis and paper partition chromatography indicated that only glucose units were present, presumably D-glucopyranose units linked β-1,4 glycosidically, in accordance with the currently accepted structure for cellulose.

The mannan was a sample of mannan A obtained by Yundt (*19*) from a chlorite holocellulose of commercial ivory nut shavings. Klages and Niemann (*20*) performed methylation studies on an ivory nut mannan A obtained by essentially the same procedure (*21*) and showed that the linkages were 1,4 and that the degree of polymerization was in the range of 70 to 86. By comparison with cellulose, optical rotation studies indicated the presence of β-glycosidic linkages.

The conditions of acetolysis and chromatography were identical with those previously used for the alpha-cellulose. The chromatographic patterns and yields of fractions are shown in Fig. 2.

It is interesting to note that the cotton and alpha-cellulose acetolyzates produce quite similar chromatographic patterns and have similar fractional yields after accounting for the differences in degree of reaction (as manifested by the content of fraction 1 in the acetolyzates). On the other hand, the mannan acetolyzate produced a different type of chromatographic pattern and had a different type of distribution of material among the fractions. For example the yields of disaccharide fractions of cotton and alpha-cellulose acetolyzates were approximately twice the yields of the monosaccharide fractions of these materials. The yield of the disaccharide fraction of the mannan acetolyzate was approximately two thirds the yield of the monosaccharide fractions of this material.

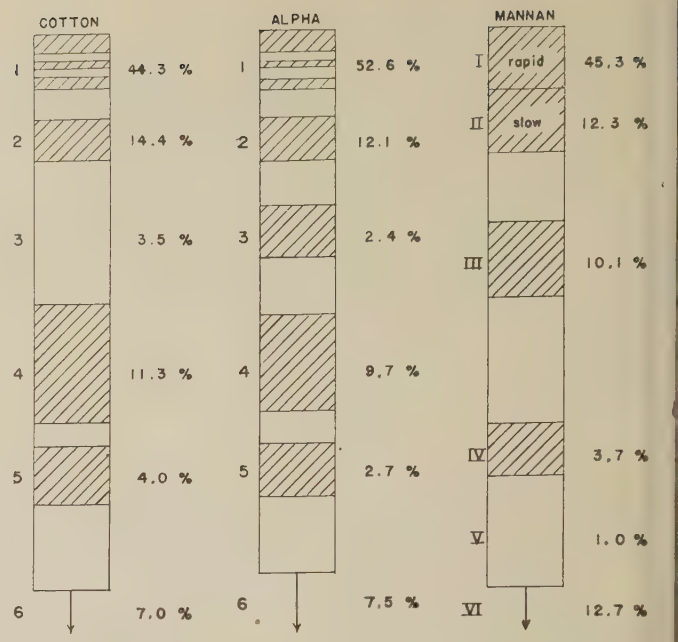

Fig. 2. Chromatographic patterns for cotton, alpha-cellulose, and mannan acetolyzates

Fractions 2, 4, 5, and 6 of the cotton and alpha-cellulose acetolyzates yielded the same crystalline products as previously found from an alpha-cellulose acetolyzate. The mannan acetolyzate yielded no crystalline materials, even after rechromatography. Upon deacetylation and paper partition chromatography, it was found that fraction III was composed largely of disaccharide material, whereas fractions IV and VI were almost entirely monosaccharidic in nature; fraction V was an intermediate area between two zones of concentrated adsorption.

Further study (by paper partition chromatography) revealed that hydrolysis of the disaccharide material yielded only mannose, and thus the material was identified as a mannobiose. There is a definite possibility that the mannose disaccharide from the acetolysis of mannan was a reversion product. It should be pointed out, however, that the disaccharide spot for the mannose subjected to acetolysis conditions was relatively weak, whereas that for the mannan acetolyzate was relatively strong (using the mannose spot as the basis of comparison). If there had been no disaccharide formed as a degradation product in the mannan acetolysis, the reverse should have been true since initially in this case there was no appreciable amount of monosaccharide material. Thus, it is probable that for mannan the disaccharide was a product of both degradation and synthesis (reversion).

The discovery of two monosaccharide zones of con-

centrated adsorption for the mannan acetolyzate warrants further investigation to determine the nature of the materials involved.

NONACETOLYTIC INVESTIGATIONS

Cupriethylenediamine and Cuprammonium Hydroxide Studies

In 1940, Lewis, Brauns, and Buchanan (*22*) developed a method for the isolation of skinlike bodies left behind as a result of careful swelling of coniferous wood pulp fibers with cuprammonium hydroxide. Nine years later, Wise, Green, and Rittenhouse (*23*) found by paper partition chromatography that this isolated skin substance was composed mostly of mannose units with lesser amounts of glucose units. On the basis of these findings, it was decided to investigate the nature of the sugar units in residues which might be obtained after treatment of the alpha-cellulose with cuprammonium hydroxide and cupriethylenediamine.

When the method proposed by Lewis, Brauns, and Buchanan was used on the alpha-cellulose, a cuprammonium-insoluble material resulted. However, when this material was hydrolyzed and subjected to paper partition chromatography, only glucose was found to be present. A similar study using cupriethylenediamine prepared according to the directions of Straus and Levy (*24*) produced the same sort of results—i.e., a cupriethylenediamine-insoluble material composed of glucose units only was obtained.

A microscopic observation of the dissolving of the alpha-cellulose in cuprammonium hydroxide revealed no ballooning of the fibers.

The "skin substance" present in coniferous wood pulps was apparently removed from the alpha-cellulose during the preparation of this material.

Oxidation with Sodium Periodate and Periodic Acid

Oxidation of polysaccharides by periodate causes rupture of carbon-to-carbon linkages between adjacent hydroxyl groups. Analyses utilizing data on formic acid production, periodate consumption, and the products of hydrolysis permit determination of the linkages present.

Sodium periodate oxidations, employing Potter and Hassid's conditions (*25*), were carried out on cellobiose, cotton, and alpha-cellulose. The reaction with cellobiose was followed by formic acid production (see Fig. 3); the yield of formic acid per mole of cellobiose was approximately theoretical (found: 2.95; theoretical: 3.00 moles of formic acid per mole of cellobiose). On the other hand, the cotton and alpha-cellulose showed formic acid yields of 0.00074 and 0.00140 (moles of formic acid per mole of anhydrohexose units), respectively. The indications were that no significant number of 1,6-linkages were present in either the cotton or alpha-cellulose, since each 1,6-linkage would produce one mole of formic acid per mole of anhydrohexose unit.

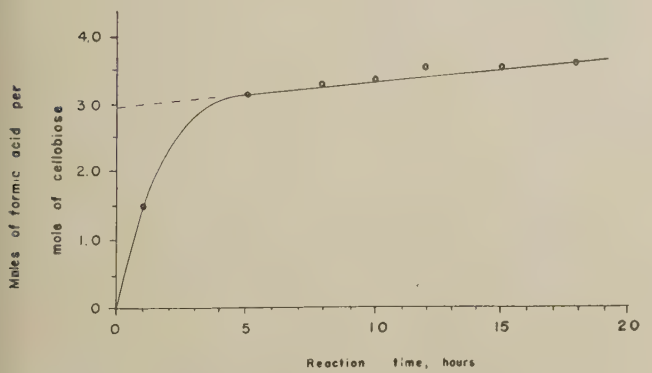

Fig. 3. Formic acid production by cellobiose

Periodic acid oxidations employing Jayme and Sätre's (*26*) conditions were carried out on cotton and alpha-cellulose. The reaction was studied by periodic acid consumption and products of hydrolysis after oxidation. After 34 hours, periodic acid consumptions were 0.93 and 1.04 moles of periodic acid per mole of anhydrohexose for cotton and alpha-cellulose, respectively. This indicates that substantially all linkages were through positions 1 and 2 or 1 and 4. After hydrolysis with 10% sodium bisulphite, the degraded products were identified on a chromatogram (as the bisphenylhydrazone and osazone, respectively) as glyoxal and erythrose (*27*). No other hydrolytic products were found. Therefore, it would appear that the linkages involved in both cotton and alpha-cellulose were substantially all of the 1,4-type.

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Application of Statistical Methods in the Coating Plant

R. T. TRELFA

The application of statistical methods to problems of routine control and to specific investigations is discussed. Actual problems arising in the paper coating plant which were solved by statistical methods illustrate the scope and value of these techniques. A problem of routine control arose in a plant in connection with the visual inspection of coated paper for defects. Charting and weighting of visual defects on a "Go"-"No Go" basis was used for control and evaluation. Testing personnel recorded their observations on a control chart which gave a continuous record of product quality and the steps taken to remedy defects. The results of this program were a marked improvement in coated paper quality and considerable savings. A problem for statistical investigation arose in an attempt to determine the cause of "brushiness" in coated papers. Data relating "plasticity index" of the coating material and quality of the coated paper were subjected to statistical analysis. Plasticity index was found to have a significant effect on brushiness and an optimum value for plasticity index was established. Incidence of brushiness was reduced to one third its former value.

COATED paper production has increased substantially during the past 15 years. While much of this increase in production has been consumed by new and expanding markets, the developing competitive picture demands higher quality coated papers at lower price. Statistical techniques are important tools for the paper coater in meeting these demands since they enable him to expand his understanding of problems resulting from technological advances in paper coating and printing processes.

The problems of routine control, research, and experimentation in coating mills are complex. Paper itself is a variable material produced in a form which often precludes representative or adequate sampling. The inherent value of coated paper is generally measured indirectly, and satisfactory quantitative testing methods are not available for the determination of many important end use characteristics. Coating colors and their components present further problems not readily amenable to normal technical approach. The mechanism of coating itself is obscure, and finishing operations pose still further complexities.

When problems are simple common sense will provide answers. Statistical methods may be said to represent common sense applied in a quantitative manner to problems too involved for normal approaches. Time and time again it has been shown that the value of statistical techniques increases markedly as technical difficulties expand, as variables increase in complexity, and cause and effect relationships become more abstruse.

Count Leo Tolstoy in "War and Peace" (*1*) states: "Man's mind cannot grasp the causes of events in their completeness, but the desire to find those causes is implanted in man's soul. And without considering the multiplicity and complexity of the conditions, any one of which taken separately may seem to be the cause, he snatches at the first approximation to a cause that seems to him intelligible and says 'This is the cause!' "

Applied specifically to statistics, Tolstoy implies that statistical techniques are no better than the man using them and that the proficiency of the user relates directly to his *understanding* of the system with which he is concerned. These points cannot be too strongly emphasized.

If statistical techniques are to pay off in a coating mill, the statistical engineer must have a thorough understanding of both statistical methods and the coating process. In initiating a quality control program, management must recognize these truths and permit ample time either to train the statistical engineer in coating practices or to train the coating engineer in statistical practices.

Statistical techniques are useful in the coating plant for both routine control and specific investigations. By routine control is meant the analysis and resolution of *recurring* problems. Specific investigations, on the other hand, refer to the analysis and resolution of problems encountered in specific projects. For most coating mills specific investigation is a necessary prelude to routine control.

The statistical techniques available to the coating engineer can be roughly divided into seven groups: (1) experimental design, (2) sampling plans, (3) control charts, (4) correlation, (5) tests of significance, (6) analysis of variance, and (7) presentation of data.

Typical questions which may be answered by these techniques are:

1. How should an experiment be carried out to assure valid results? A knowledge of experimental design will materially aid in the collection and interpretation of experimental data.
2. What constitutes a sample? Sampling plans are of maximum value in determining both the validity of a sample and the significance of that sample in terms of process or product quality.
3. How effectively can the coating plant (or processing unit) operate if variations due to extraneous, controllable factors are eliminated? Control chart techniques are specifically designed to answer this type of question.
4. Are test results valid in defining end use requirements? What are the relationships between variables? Correlation techniques will be of particular value in answering such questions.
5. Are two coating machines (or process units) comparable in performance? Here tests of significance have maximum usefulness.
6. What are the sources of variability in coated paper (or coating raw materials)? In answering such questions, analysis of variance technique is of maximum value.
7. How uniform are the products produced by the coating plant (or processing unit)? Presentation of data techniques will give straightforward answers.

There are many ways of following coating mill operations. In an individual mill, tests might be carried out,

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recorded, and charted along a time axis according to grade, operating unit, unit operation, order, grade subdivided to basis weight, or combinations.

Regardless of the method selected, the system should fulfill, in approximate order of importance, the following requirements:

1. The information should be readily available to mill operators and in a form such that the need for immediate action can be recognized as soon as that need exists.
2. The information should be available to supervisory personnel in a form which will enable them to evaluate operation performance in a given previous time period so corrective measures may be taken if indicated.
3. Data should be in a form suitable for evaluating sales problems or customer complaints.
4. Information should be in a form to emphasize problems which could profitably be specifically investigated.
5. Data should be available to top management in a form to permit accurate evaluation of period-to-period efficiency, productivity, and quality performance.
6. The information should be in a form suitable for record purposes and further statistical study.

DEVELOPMENT OF CONTROL CHART FOR VISUAL DEFECTS

Many important properties of coated paper can be determined only by visual inspection. Control of these properties is particularly important because of their direct effect on salability of the coated paper.

A coating mill, manufacturing book and label papers on conventional brush coaters, developed control charts for such visual defects as part of an over-all quality control program. A summary of this development for coating defects is presented to illustrate the planning and organization which are necessary prerequisites for the successful introduction of control charts in the coating plant.

While the ultimate goal of the quality control program was to develop control charts for visual defects according to the methods of Catlin and Strieby (*2*), intensive preliminary investigation was necessary.

A routine sampling plan was set up for re-examination of sorting room rejects and seconds. This routine served two purposes: to determine major coating defects and to permit evaluation of quality changes as the program proceeded. Major sources of rejection or downgrading were: (1) poor coating (brushy, streaks, skips, etc.), (2) pinholes, (3) duplex and shade, and (4) spots.

A series of standard samples was accumulated for all grades to illustrate normal, inferior, and superior quality papers for each of these defects. A permanent quality control committee consisting of technical, operation, and sales representatives was organized to set up these standards and to function in a referee capacity as the program progressed. In case of conflict the judgment of sales personnel was given maximum weighting.

At this point preliminary control charts, as shown in Fig. 1, were initiated.

Testing personnel were provided with rubber stamps of the six symbols shown in Fig. 1 and blue and red ink pads. Production samples of the coated paper were then evaluated as follows: If normal quality, a blue dot was stamped on the "Go" line. If superior, a blue dot was placed on the "Superior" line. If defective, a red point was placed on the "No Go" line according to the defect noted. When a sample had more than one

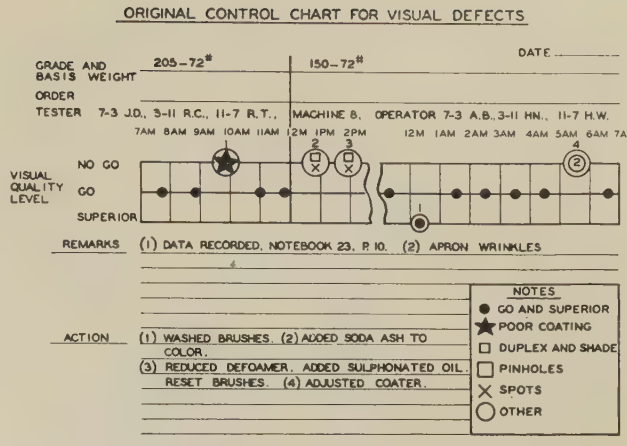

Fig. 1. Original control chart for visual defects

"No Go" defect, all pertinent symbols were shown vertically one above the other. If the defects were other than those with specific symbols, the tester used the open circle symbol, placing a number in the circle and identifying the defects under "Remarks."

Whenever a red mark appeared on the "No Go" line, the coating machine operator was required to circle the point in red and note under "Action" the measures taken to get out of trouble. When three successive red symbols appeared on the chart the coating machine was immediately shut down and special action was taken. Quality control personnel segregated information on raw stock, coating color, operator, and the like, for "Superior" samples to permit further study.

All "Go" and "Superior" rolls were tagged with blue control tickets and handled routinely in subsequent processing operations. "No Go" rolls were tagged with red control tickets containing complete information on the defect, machine, grade, etc. All "No Go" rolls were examined by quality control and operating supervisors within one hour after occurrence. If, for reasons of economics, customer requirements, or similar cause, the roll was permitted to continue in process, the red control ticket was initialed by the supervisors and stamped with a green "Go." All such rolls received special attention in following operations. All "No Go" rolls not handled by immediate supervisors within the hour were placed in a special defective paper area. Each day the quality control committee evaluated these rolls and made final disposition.

This phase of the program was continued for one year with considerable improvement in paper quality. Analysis of "Action" comments relative to coated paper quality during this period resulted in considerable savings by reduction in the number of materials used and actions taken to get out of trouble. Many "traditional" remedies for coating defects were found generally ineffective and much was learned about cause and effect relationships.

While the charts in this form were generally satisfactory for quality control, at times the coated paper was defective through a combination of defects, any one of which by itself was not serious.

During this introductory period, the quality control committee developed weighting factors and established standard samples for all recurring defects. Defects

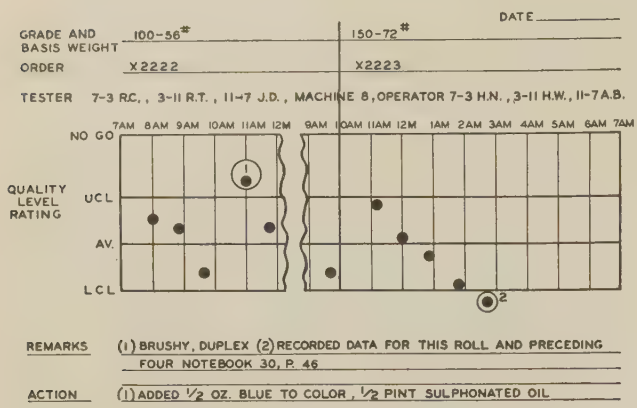
FINISHED CONTROL CHART FOR VISUAL DEFECTS
DATE
GRADE AND BASIS WEIGHT
100-56#
150-72#
ORDER
X2222
X2223
TESTER 7-3 R.C., 3-11 R.T., 11-7 J.D., MACHINE 8, OPERATOR 7-3 H.N., 3-11 H.W., 11-7 A.B.
7AM 8AM 9AM 10AM 11AM 12M 9AM 10AM 11AM 12M 1AM 2AM 3AM 4AM 5AM 6AM 7AM
NO GO
QUALITY LEVEL RATING
UCL
AV.
LCL
REMARKS (1) BRUSHY, DUPLEX (2) RECORDED DATA FOR THIS ROLL AND PRECEDING FOUR NOTEBOOK 30, P. 46
ACTION (1) ADDED 1/2 OZ. BLUE TO COLOR, 1/2 PINT SULPHONATED OIL

Fig. 2. Finished control chart for visual defects

were classified as to severity in four groups adapted from Catlin and Strieby (*2*) as follows:

Class A defects..... 100 demerits
Class A defects make the coated paper unusable. The presence of hard color lumps is an example of Class A defects.

Class B defects..... 50 demerits
Class B defects cause serious downgrading of the paper and seriously affect its salability and use. Excessive pinholes, spots, duplexing, and brushiness are examples of Class B defects.

Class C defects..... 10 demerits
Class C defects are moderately serious. Sales value is impaired and adjustments may be required by the user to obtain satisfactory results. Noticeable spots, pinholes, and mottle are Class C defects.

Class D defects..... 1 demerit
Class D defects are minor in nature but may affect salability. Detectable spots, pinholes, and brushiness are examples of Class D defects.

After weighting factors were initially assigned to all known recurring defects, their validity was checked through special "pilot" charting and corrections made where indicated. By the end of the year, these weighting factors were established on a sound basis, tentative grade average "quality levels" and control limits calculated (see Appendix A), and the control chart shown in Fig. 2 was introduced.

By reference to Fig. 2 it will be noted that the finished chart was gridless and included four horizontal lines representing, respectively (top to bottom) "No Go" limit, upper control limit, average quality level, and lower control limit. Ordinary control charts use a fixed scale with variable control limits; gridless charts use a variable scale with fixed control limits. Thus, in the chart of Fig. 2, the average quality level line could represent 30 for one paper grade and 12 for a second grade. Similarly, the vertical distance from average quality line to upper control limit (or lower control limit) could represent any number of quality level units depending on the quality level variability of the grade being plotted.

Transparent celluloid strips were used for locating all points. These strips were separately scaled for each coating machine and grade. Thus at no time was the machine operator concerned with the actual quality level rating of the paper (or the numerical spread of control limits), but only with its position relative to control limits.

Since only one stamp was now used to record data, one minor tester innovation was necessary. Since action was required whenever a red point appeared on the chart, the tester numbered each red point in sequence and under "Remarks" recorded the major defects noted in the corresponding coated paper sample. The machine operator circled the point as before and recorded the corrective measure taken under "Action" using the number assigned by the tester.

Under the new system, superior, normal, and "No Go" rolls were tagged and handled as before. Rolls out of control (but not "No Go") were tagged in green and continued in process only after the tag was initialed by a quality control representative. This innovation served both to highlight quality performance of the mill and to permit segregation of out-of-control rolls for further study if desired. The coating machine was now shut down after one "No Go" point appeared or three successive red points (not "No Go"). Approval by mill supervisors was required before production was reinitiated.

The finished charts were superior to the original charts as noted:

1. Coated paper quality could be measured quantitatively.
2. Since one set of standards was used in determining quality level of all grades, grade differences could be judged in terms of quality level differences.
3. Since control limits were more stringent than original "No Go" limits, preventive action could frequently be taken before unsalable paper was produced.
4. The use of only one rubber stamp simplified tester routine and simplified chart interpretation.

STATISTICAL INVESTIGATION

It is well known that many factors can affect the "brushiness' of paper coated on conventional brush coaters. Condition of brushes, machine adjustment, raw stock, and coating color flow properties are among these factors.

In the course of a coating mill survey it was noted that one grade of coated paper was consistently more brushy than others. Control records permitted identification of coating color with coated paper roll. Among other control tests, the subject mill determined coating color viscosity at two rates of shear using a Brookfield viscometer. From these viscosities, a value known as the "plasticity index" was calculated (*3*, *4*) (Appendix B).

Roll samples were examined visually by testers who simply recorded whether the sample was brushy. Since the severity of brushiness was not noted, no weighting factors could be used to give numerical measure of the defect.

In investigating sources of brushiness, tester notations were compiled on 813 rolls along with plasticity index data on the corresponding coating colors. Accumulated data are shown in Table I.

From the totals of Table I, it can be seen that 637 of the 813 rolls were nonbrushy and 176 were brushy. We could logically expect that if coating color plasticity index had no effect on brushiness of the coated paper, each plasticity range would produce, within limits, these same proportions of brushy and nonbrushy rolls. For example, it will be noted that coating colors in the plasticity index range 0.3 to 0.4 were used in producing a total of 117 rolls of coated paper. From

the over-all totals, it would be expected that (637/813) × (117) or approximately 92 rolls would be nonbrushy and (176/813) × (117) or approximately 25 rolls would be brushy.

Such expected values, as well as the arithmetic differences between observed (mill data) and expected values, were similarly calculated for each plasticity range and assembled in Table II.

By inspection of Table II, it can be noted that coating colors with plasticity indices in the range of 0.5 to 0.6 actually produced less brushy paper than expected, while all other coating colors produced more brushy paper than expected.

To determine whether the difference was significant, the Chi Square[1] value was calculated (see Appendix C). Chi Square is defined as the sum of the squares of the differences between observed and expected values divided by the expected values. By squaring, dividing, and summing, a Chi Square value of 16.49 was obtained.

This value was checked against a Chi Square table (*5, 6*). It was found there was less than one chance in one hundred Chi Square would be this large if coating color plasticity index had no relationship to coated paper brushiness. It was, therefore, concluded that coating color plasticity index did relate to brushiness of coated paper, and that coating colors with plasticity indexes near the range 0.5 to 0.6 were most desirable.

Subsequent investigations identified the major factors affecting coating color plasticity index and permitted control of the index within suitable limits. Ultimate control limits on coating color plasticity index were established at 0.54 to 0.64. Under these conditions, the incidence of brushy paper in the grade investigated was reduced to one third of its former level.

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APPENDIX

A. Calculation of Quality Level, Average Quality Level, and Quality Level Control Limits:

d_A = number of Class A defects in sample
d_B = number of Class B defects in sample
d_C = number of Class C defects in sample
d_D = number of Class D defects in sample
QL_1 = quality level of sample 1
AQL = average quality level

$$QL = 100d_A + 50d_B + 10d_C + 1d_D$$

$$AQL = \frac{QL_1 + QL_2 + \cdots + QL_n}{n}$$

At the start of the program, control limits were calculated according to the ASTM method for c (*7*) as follows:

$$\text{Control limits} = AQL \pm \sqrt{AQL}$$

These limits were found unsuited to the process and the control chart method for variables applied as follows (*7*):

R = range or numerical differences between highest and lowest values in a subgroup
n = number of observations in a subgroup
$\bar{R}$ = average range
E_2 = control chart factor (*7*) for subgroup with n observations

$$\text{Control limits} = AQL \pm E_2\bar{R}$$

These limits were satisfactory for process control.

B. Plasticity Index:

Plasticity index = $(\log \eta_1 - \log \eta_2) \div (\log \omega_2 - \log \omega_1)$, where η_1 is the apparent viscosity at rate of shear ω_1 and η_2 is the apparent viscosity at rate of shear ω_2. If a coating color has a viscosity of 200 cp. (η_1) at 6 r.p.m. (ω_1) on the Brookfield Synchrolectric Viscometer and a viscosity of 100 cp. (η_2) at 30 r.p.m. (ω_2) with the same bob, the plasticity index is (log 200 − log 100) ÷ (log 30 − log 6) or (log 200/100) ÷ (log 30/6)

$$\log 200/100 = \log 2 = 0.30103$$
$$\log 30/6 = \log 5 = 0.69897$$
$$\text{Plasticity index} = 0.30103/0.69897 = 0.43$$

C. Chi Square Calculations:

O = observed values
E = expected (calculated) values

$$\chi^2 = \Sigma[(O - E)^2/E]$$

From Table II

$$\chi^2 = 8^2/25 + -8^2/92 + 7^2/53 + \cdots + -3^2/28$$
$$\chi^2 = 2.560 + 0.695 + 0.925 + \cdots + 0.322 = 16.49$$

Since there are five plasticity classes, the degrees of freedom are 5 − 1 = 4. The probability that χ^2 will exceed 13.28 by chance alone is less than 0.01. Therefore, χ^2 is significant.

Table I. Mill Data on Brushy Paper

Plasticity index range	*Number of rolls*		
	Brushy	*Nonbrushy*	*Total*
0.3–0.4	33	84	117
0.4–0.5	60	185	245
0.5–0.6	25	176	201
0.6–0.7	47	167	214
>0.7	11	25	36
Total	176	637	813

Table II. Frequency of Brushy Rolls

Plasticity index range	*Roll class*	*Number of rolls*		
		Observed	*Expected*	*Difference*
0.3–0.4	Brushy	33	25	8
	Nonbrushy	84	92	−8
0.4–0.5	Brushy	60	53	7
	Nonbrushy	185	192	−7
0.5–0.6	Brushy	25	44	−19
	Nonbrushy	176	157	19
0.6–0.7	Brushy	47	46	1
	Nonbrushy	167	168	−1
>0.7	Brushy	11	8	3
	Nonbrushy	25	28	−3

[1] For clarity, calculated values are rounded and no correction is applied for noncontinuity. These measures have no effect on the conclusions drawn

High Pressure Paper Dryers

C. P. SPALDING

There is an increasing interest in high pressure driers in order to increase drying capacity. On a new machine it is sometimes better to design for low pressure due to steam balance, but to install high pressure driers for future expansion. On a rebuild these should be used if the sheet can be dried at high temperature. This question should always be studied with care. Both Yankee and paper driers can be furnished for pressures up to 160 p.s.i. in cast iron and in steel for even higher pressures.

IN RECENT years there has been an increasing interest in the use of higher steam pressures for paper machine driers prompted by the increase in production made possible in this manner. In this paper we shall present some comments upon the use of higher steam pressures and discuss the present-day limitations from the standpoints of construction and effect upon the sheet. Before doing so, however, it might be well to point out that it is usually wise to proportion drying equipment so that the required capacity can be obtained by using quite moderate pressures.

When a new machine installation is being laid out or where there are no space or other limitations to the size of the drier section an economic study based upon the steam and power balance of a particular mill will usually show that an amply proportioned drier section is a good investment because mechanical or electrical power can be gained. This assumes, of course, that the steam at boiler pressure is passed through a prime mover, the back pressure upon this prime mover being determined by the operating pressure needed for the drier section. The particular factors in each proposed installation will, of course, determine the best balance, but it is common for such a study to show that an operating steam pressure in the neighborhood of 50 pounds gage would give the best balance.

There is a further and very practical consideration pointing toward the selection of a moderate operating pressure for a new installation and that is the fact we almost invariably find paper machine installations increasing from their original tonnage expectations to higher and higher figures over the life of the mill, so that many machines are now producing two or three times the tonnage originally expected. Anyone who has been involved in the major re-build of a machine involving lengthening of the drier section with the consequent movement of calender stacks, lengthening of foundations, loss of machine production during the re-build, and the various other complications that are involved will agree that an amply proportioned drier section which avoids an early re-build of this character is invariably a very fine investment.

In spite of generous proportioning of the original drier section the time usually does come when more drying capacity is required, and often this occurs under circumstances where space or other limitations make an increase in the number of driers either impossible or extremely expensive. In some cases higher steam pressures can then be used to good advantage and, consequently, it is recommended that driers provided for new machines or re-builds be built and tested for the maximum pressures allowable.

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DRIER PRESSURES

The allowable working pressure for a drier is today determined by its design and by the prevailing State and A.S.M.E. codes. Assuming a favorable design, the codes have the effect of limiting cast-iron driers to a maximum pressure of 160 pounds gage, while steel driers can be designed and approved for operation at materially higher pressures. Here we should add that these comments apply to steam-heated driers, and that the use of other heating media is not very practical, all factors considered.

The various codes and insurance regulations which impose these limitations on operating steam pressures were, of course, established to safeguard against injury or loss of life caused by drier failures or explosions, together with the attendant monetary losses, When we consider the number of paper machine driers in operation today and the fact that drier failures occur very infrequently, it becomes quite evident that these regulations have provided a very adequate safety factor.

The effectiveness of high pressure can be indicated by referring to a typical case where the increase in steam pressure from 30 to 75 p.s.i. gives us increase in drying effect of over one third. Similarly, if we go from 30 to 125 pounds, the drying rate is increased over one half. It would be convenient if we could develop a simple formula from which we could calculate the increase in drying capacity with increase in steam pressures, but factors such as machine ventilation, drier felt arrangement and condition, and so forth, make this impossible. Field information and observation are the only ways for anticipating these increases. For our purposes here, it is sufficient to note that the increase in drying rate through the use of high pressure steam is very well worth investigating.

DRIER TEMPERATURES

It is important in such studies to first consider the nature of the sheets to be dried because some sheets are definitely injured by high temperature. An extreme case would be a highly beaten fine glassine sheet; such paper is always dried at a low steam pressure since otherwise it would be injured by cockling and loss of its greaseproof character. Many groundwood sheets, even the well-known newsprint, would suffer if subjected to too high temperature. Some special boards, particularly those made on multi-

cylinder vat machines, have been injured in high temperature drying from such conditions as separation of plies, so-called case hardening, loss of folding qualities, etc. On the other hand, unbleached kraft sheets starting with bag and wrapping grades, and continuing into the heavy fourdrinier container board, are getting along well with high pressure drying. Bleached kraft sheets are almost as stable under high drying temperatures with some indicated loss of color at extremely high temperatures. Experience in the sulphite wrapping grades at high drying temperatures hasn't been very extensive. There is a good possibility, however, that with somewhat higher temperatures than may have been previously used, it could be dried successfully.

The comments we have made on the effect of temperature in drying various types of paper apply when a Yankee drier is used. Freer types of stock handle well and high pressures have been used very successfully. Tissue, both flat and creped, and some waxing grades, dry well at high temperatures. Actually, it was the Yankee drier that first led us into the high pressure drier development. The speed of a Yankee machine is limited by the drying capacity of the Yankee. We couldn't use driers larger than 12 feet in diameter because of shipping restrictions so that the next most feasible step was to increase the steam pressure to obtain additional capacity in the machine.

Prior to 1927 all of our Yankee driers, and as far as we know, most of the foreign driers, were designed for a maximum steam pressure of 25 to 30 p.s.i. At this time we re-designed our driers for a maximum of 45 pound steam pressure. With the resulting increase in speed we had trouble removing the condensate and so developed a high speed water remover to overcome this difficulty. We again re-designed our Yankees in 1935 for 75 p.s.i. and since then have increased this pressure to 125 pounds.

DRIER ROLL DEVELOPMENT

In 1937 we developed a steel drier. This was unsatisfactory for several reasons. The paper showed wet streaks at the welds, it didn't hold its shape well, it didn't dry as fast as we had anticipated, and we could not doctor the sheet properly. We tried various doctor materials but none proved too satisfactory. This was partially due to the difference in hardness of the steel at the welds and partially to the basic structure of steel as compared to the granular structure of cast iron. The free graphite in the cast iron seems to help to lubricate the doctor. We therefore replaced this with one of our standard cast-iron driers of the same wall thickness which dried more paper at the same steam pressure since the sheet was more evenly dried.

At this time we also made an experimental drier using a brass shell in order to increase the rate of heat transfer but here also we encountered doctoring trouble.

In the original low pressure Yankees the thickness of the shell was determined by the stiffness required for the pressure roll, but as we went to higher steam pressures with the metal available at that time we had to increase the wall thickness. With these higher steam pressures we didn't obtain a comparable increase in drying rates.

The heat transfer through a drier shell is made up of three coefficients; the transfer through the film between the steam and inside of the shell, through the drier wall, and through the film between the wall and the paper. Therefore, when we increase the wall thickness we decrease the total heat transfer. For example, when we increase the shell thickness from 2 to 3 inches the total transfer in a Yankee is only 75% as efficient.

In a 2-inch wall Yankee we lose about 2% through the inner film, 72% through the wall, and 22% through the outer film.

From the above data it is apparent that as the wall thickness is increased the drying rate will be decreased. To overcome this loss in drying rate, therefore, we made experiments so that we could get a stronger iron with the same thickness of the wall. We have in recent years doubled the tensile strength in our drier shells.

The author previously said that we didn't make Yankees over 12 feet in diameter because of shipping restrictions. It is interesting to note that in the case of high pressure driers we would not gain much, if anything, in drying capacity with larger diameter driers since we would have to materially increase the wall thickness for the same steam pressure.

In paper driers the basic design problems are the same as in the case of Yankee driers, as outlined above. We have designed a cast-iron 60-inch paper drier suitable for 160 pounds pressure. For higher steam pressures we have designed and used steel driers, both of our own design and purchased complete outside.

In paper driers the shell thickness is of much less importance than in Yankees due to the slow transfer between the shell and paper. In the case of a drier with a 1-inch wall, for instance, there is approximately 2% loss through the internal film, 10% through the wall, and 88% through the external film.

For 125-pound steam pressure we would use a cast-iron drier with a $1^1/_8$-inch shell or a steel drier with a $^3/_4$-inch shell. Theoretically, we would expect the steel drier to give us about 3.5% greater capacity than the cast-iron drier under these conditions. Actual results on one installation with which the writer is familiar seem to bear out these figures fairly well. However, we feel that this small gain in capacity is more than offset by the greater stability, resistance to corrosion, and decrease in wear due to doctoring of the cast-iron drier.

LUBRICATION

In the use of high pressure driers the problem of lubricating bearings becomes more serious due to higher bearing temperatures. To keep this temperature as low as possible we use patented insulating sleeves in the back journals which materially decrease this temperature. The mill should also desuperheat the steam to the driers for the same reason. Select the proper grade of oil to meet these special requirements.

Felt life is largely dependent on keeping the machine running. If a machine has frequent breaks the hot driers will cause rapid deterioration of the felts. However, with steady operation the felt life has not been a serious problem but is reduced.

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A Shear Criterion for the Hydraulic Behavior of Paper Stocks in Pumps, Pipes, Valves, and Flowmeters

VICTOR P. HEAD

Apparent viscosity of a non-Newtonian fluid is not a fluid property, nor does it have meaningful physical dimensions in mass-length-time in the absence of completely defined flow geometry. The slope and intercept of the shear diagram are truly fluid properties which remain constant over wide ranges of shear rate and which have the physical dimensions of viscosity and of stress, respectively. The terms *slope viscosity* and *apparent yield stress* are proposed as descriptive of these properties. The definition of viscosity might well be altered to mean the slope of the shear diagram, while the difference between true and non-Newtonian fluids would be expressed merely by the value of the apparent yield stress, which is, of course, zero for Newtonian fluids. Slope viscosity assumes a negligible role and yield stress in shear a dominant role in the flow of paper stock in pipes, pumps, valves, and flowmeters. A shear criterion has permitted very precise correlation of the flow coefficients of variable-area flowmeters in stock service, and a fiber-length criterion has shown the limits of validity of the shear criterion. Promise of equal success in the case of pipe friction appears evident, and it is hoped that the yield-stress concept will prove useful in many other phases of paper engineering.

THE viscosity of a true fluid is the ratio of an applied shear stress to the resulting shear rate in the absence of turbulence. The term viscosity as a fluid property independent of test conditions must have had its origin in the observation that various experimental values of shear stress and shear rate for one particular fluid yielded a curve of shear stress versus shear rate, or a *shear diagram*, which was a straight line passing through the origin. Laboratory viscosimetry applied to true fluids is always based on the assumption that a single test point is sufficient to establish the shear diagram, the origin being taken as an additional assumed point. The shear diagram was necessarily a prior concept, and when a shear diagram fails to conform to the straight line through the origin, the word viscosity, without more careful definition, becomes meaningless. This may be readily appreciated when it is considered that, for example, a 2.5% consistency sulphite stock may exhibit so-called viscosities from the 0.3 cp. minimum of Guenter and Ceaglske (*1*) to over 30,000 cp. in the tests described herein.

Since such a "viscosity" obtained from a particular experiment can only be used to predict results for an exact repetition of that experiment, its determination offers no technical advantage and merely complicates the presentation of results. Unless a new definition of the word viscosity may be formulated which is once again a fluid property, remaining constant in value over a wide range of test conditions, the word had better be abandoned for non-Newtonian flow. Fortunately, such a redefinition is possible, as we shall see.

The shear diagrams of many non-Newtonian fluids are straight lines throughout the region of shear stresses and shear rates of industrial hydraulic interest. They differ from the shear diagrams of Newtonian fluids in failing to pass through the origin. The *slope* and the *extrapolated intercept* of the shear diagram constitute fluid properties on which various laboratories may agree, and these properties may be given the names *slope viscosity* and *apparent yield stresses*. They are dimensionally as different from each other as are viscosity and pressure. Therefore non-Newtonian flow can only be correlated by a new parameter to account for the influence of yield stress, just as the flow of compressible fluids demands a separate parameter to account for the influence of elasticity.

We propose, therefore, a new definition of viscosity as *the slope of the shear diagram* for all fluidmechanics work. We will, however, use the term *slope viscosity* in this sense for the time being to avoid confusion with the various terms that have been used up to now for the apparent viscosity.

We further propose the term apparent yield stress, s, and define it as the intercept on the shear-stress ordinate obtained by extrapolating the linear portion of the shear diagram to zero shear rate.

When Reynolds numbers are calculated from slope viscosities, they will have meaning for a wide variety of non-Newtonian fluids and flow conditions.

Apparent yield stress, s, having units such as pounds per square inch shear, demands a new parameter, and the simplest will be the ratio of s to the differential pressure, ΔP, over a defined set of flow boundaries.

Choosing S as our symbol for this parameter, we have:

$$S = \frac{s}{\Delta P} \qquad (1)$$

This is the proposed *shear criterion* for non-Newtonian fluids. It may expected to supplement and, in certain limited cases, to replace one or more of the familiar criteria of fluid mechanics.

SULPHITE AND GROUNDWOOD SHEAR DIAGRAMS

Tests conducted by the author with the cooperation of Dilts Machine Works in Fulton, N. Y., in April, 1950, show that in spite of apparent viscosities of hundreds of thousands of centipoises, the slope viscosities of sulphite and groundwood stocks remain close to that of water, while apparent yield stress becomes the dominant characteristic.

A crude "shear tester" was constructed at Fulton to determine shear diagrams for the groundwood and sul-

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phite stocks of various consistencies which were used in the flowmeter tests described below. This tester was essentially a "viscosimeter" of the concentric cylinder type, but of such great size that the lengths of stock fibers were small by comparison. The dimensions of the tester are shown in Fig. 1. Wire bristles on

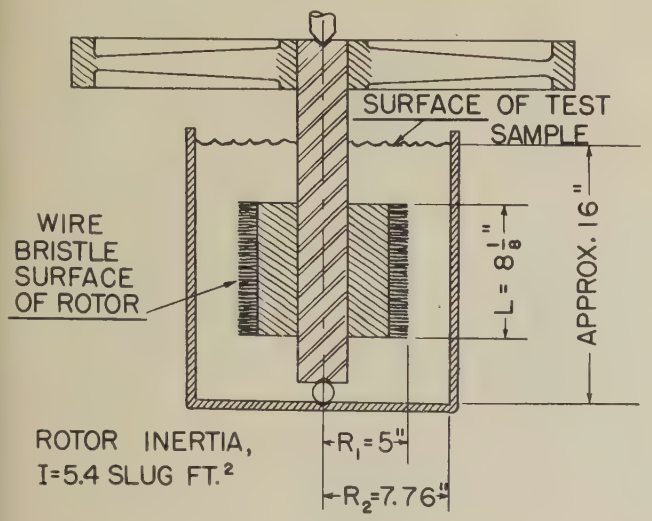

Fig. 1. Shear tester

the rotor surface prevented separation and water slip, to assure that the stock was actually subjected to shear. It is believed that the smooth surfaces of the rest of the rotor permitted slip and minimized end effects not included in the equations. The rotor was cranked by hand and then timed as it coasted to a stop, the number of revolutions being recorded to the nearest tenth of a revolution. Timed coasting intervals ranged from some 30 seconds for water down to 1 or 2 seconds for 7.2% sulphite, which explains the progressive increase in point scatter with increasing consistency on the shear diagram, Fig. 2.

If employed to determine the viscosity, μ, of true fluids, the equation of the device would be, in any consistent units:

$$\mu = \frac{I(R_2 - R_1)(\ddot{\theta} - \ddot{\theta}_0)}{2\pi R_2 R_1^2 L \dot{\theta}} \qquad (2)$$

where $\ddot{\theta}$ is the average angular deceleration, $\ddot{\theta}_0$ is the deceleration produced by bearing friction obtained from data for water, and $\dot{\theta}$ is the average angular velocity. I is the mass moment of inertia of the rotor, calculated to be 5.4 slug square feet. The lengths R_1 and R_2 and L are given in Fig. 1. In deriving equation (2) we have recognized the variations in shear stress and shear rate that would exist at various radii between rotor and container in the testing of true fluids. The quandrant scale of centipoises on the shear diagram, Fig. 2, is based on equation (2). For non-Newtonian fluids the slope viscosity could be read on the quadrant scale, not from the shear diagram but from a line parallel to the shear diagram and drawn through the origin (that is, the point where $\dot{\theta} = 0$ and $\ddot{\theta} = \ddot{\theta}_0$). Further, the velocity gradient for non-Newtonian fluids will not be a smooth decrease from R_1 to R_2, but rather a rapid decrease to zero, a very short distance from the rotor, leaving most of the annulus occupied by fluid which is not sheared at all. Thus shear rate becomes, in the non-Newtonian case, virtually imponderable, while only that shear stress, s_1, which exists close to the rotor surface is meaningful.

$$s_1 = \frac{I\ddot{\theta}}{R_1^2 L} \qquad (3)$$

where $\ddot{\theta}$ must be in *revolutions* (rather than radians) per time squared and any consistent units may otherwise be employed. The shear stress ordinate which accompanies the deceleration ordinate in Fig. 2, is based on equation (3).

Consider the shear diagram for 4.33% groundwood, the dashed line of Fig. 2. Using the conventional definition of viscosity, the slope of a line connecting the origin and the test point, the apparent viscosities would range from 40,000 to 200,000 cp., while it is obvious that, had means been available to drive the rotor at higher speeds, or timing facilities available to obtain accurate results at lower speeds, the test range might have yielded a band of apparent viscosities from as low as 4000 or perhaps 400 cp. up into the millions. Obviously such numbers are meaningless. It is equally clear that the slope of the line is zero within the sensitivity of the device, so that the slope viscosity lies somewhere between 0 and a few hundred centipoises and may be assumed, for a guess, to equal that of water, while the really useful information to be derived from the test is the value of the yield stress, s = 0.72 p.s.i. Similarly, for sulphite stocks of various consistencies, the slopes are zero within the accuracy of the equipment, and the yield stresses may be read from the shear diagram.

It is optimistic to hope that those characteristics of various paper stocks which contribute to the qualities

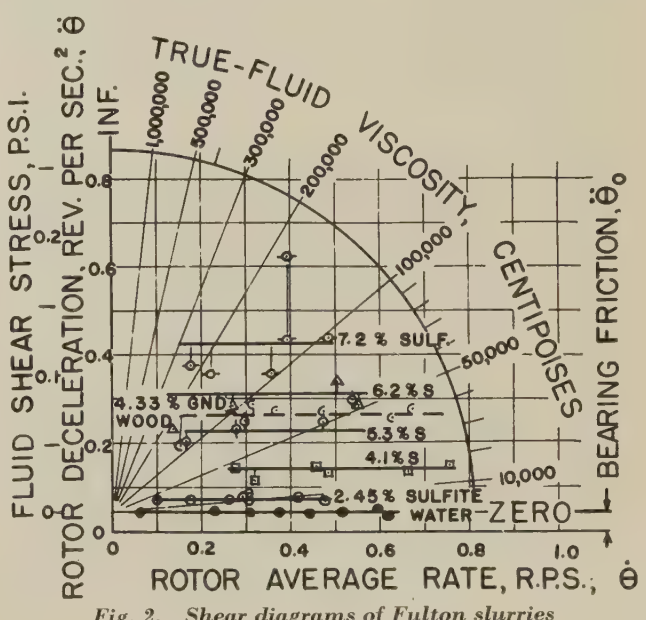

Fig. 2. Shear diagrams of Fulton slurries

of the paper are necessarily those which determine the hydraulic properties of the slurry. Nevertheless, an empirical equation may be of some value. The difference in yield stresses of sulphite and groundwood at equal consistencies must depend upon fiber characteristics, and we have assumed that fiber length, j, is of utmost

importance. A decrease in fiber length with no change in consistency necessitates the presence of a larger number of fibers, larger diameter fibers, or both, and a greater randomness of fiber orientation under flow conditions with a consequent increase in yield stress. While a questionable substitute for a laboratory determination, the following equation derived from the shear diagrams of Fig. 2 has proved useful in estimating yield stresses.

$$s = 0.00057 \frac{X^{2.4}}{j^{0.41}} \qquad (4)$$

where s is yield stress, p.s.i. shear. X is consistency, per cent moisture-free, and j is the fiber length, inches, determined crudely by tearing a wet sheet of the stock, laying the torn edges side by side on a contrasting background with the majority of fringes touching, and measuring the width of the visible background in several places and averaging. For the Fulton tests, sulphite fiber length was 0.2 inch and groundwood 0.04 inch. It will be seen below that fiber length imposes an additional geometric criterion, quite apart from its effects on yield stress which is associated with the dimensions of flow passages.

SHEAR PARAMETER FOR PIPE FRICTION

The mere presence of particles or fibers far above microscopic size suggests that the development of turbulence in pipe flow should be drastically retarded, while friction losses due to shear alone should be high and proportional to yield stress. The influence of the Fanning friction factor should therefore be minimized and that of the shear criterion, S, of utmost importance. It is physically permissible to employ the Fanning plot of friction factor, f, versus Reynolds number, so long as Reynolds number is calculated from physically significant slope viscosity and not from apparent viscosities. A family of curves must then be expected, each curve bearing a particular numerical value of

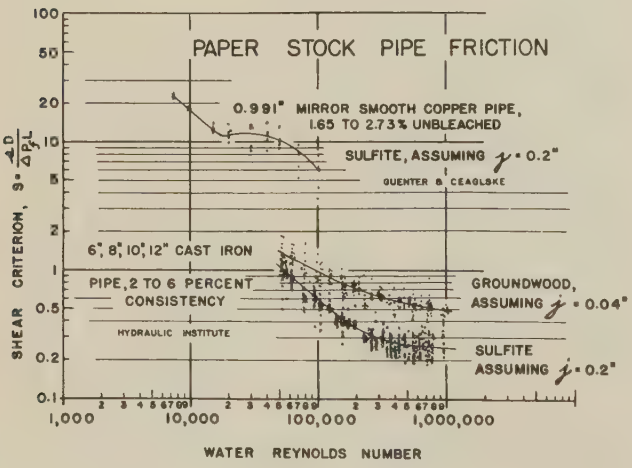

Fig. 3. Correlation of shear losses in pipes

the shear criterion, S. The already available Fanning plot for true fluids provides one of these S-lines, namely $S = 0$.

Fluids such as paper stock which have very low viscosities and very high yield stresses, may be expected to behave, in sufficiently rough pipe, exactly as they behaved in the shear tester. That is, the pressure drop should be exactly that which is required to develop the yield stress at the pipe wall, and should remain close to this one value over a wide range of flow rates, until sufficiently high Reynolds numbers produce turbulence in spite of the calming influence of the fiber, or until

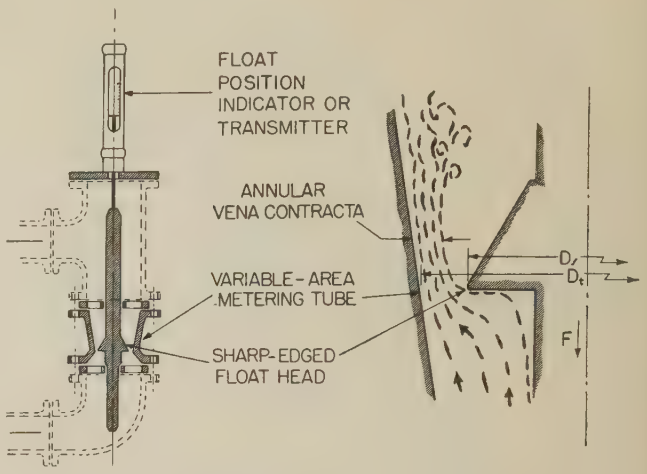

Fig. 4. Variable-area flowmeter: typical installation; flow pattern

sufficiently low Reynolds number permits dewatering close to the pipe wall and some droop in friction as a result.

Now, if pressure drop were independent of flow velocity, the Fanning plot would be unnecessarily complex, yielding a family of curves of log f versus log R having slopes of -2 and coefficients which depended only on S. The slope of -2 must result, in the absence of any velocity influence, merely because f is proportional to V^{-2} when ΔP_f is constant, while R is proportional to V. In such a case, we may replace the Fanning equation with a very simple friction loss equation:

$$\Delta P_f = \frac{sL}{SD} \qquad (5)$$

This equation assumes that ΔP, equation (1), is the pressure drop from end to end of a cylindrical flow passage whose length is equal to its diameter, while ΔP_f, is the corresponding friction loss in any length of pipe, L.

When the value of the shear criterion, S, is known, the friction loss may be immediately calculated. A theoretical value of S may be predicted for very rough pipes, or for hypothetical pipes having interior surfaces coated with wire bristles comparable to the rotor of the shear tester. Here we assume "plug" flow, with all shear close to the pipe wall. Such a pipe would be in itself a "shear tester." The force producing shear would be the pressure drop, ΔP_f, times the cross-section area of the pipe. The area of the shear surface would be the circumference of the pipe times the length, L, of pipe over which the pressure is measured. The shear stress, s, at the pipe wall, would then be:

$$s = \frac{\Delta P_f \ (\pi D^2)/4}{\pi DL} = \frac{\Delta P_f D}{4L} \qquad (6)$$

Substituting (6) in (5) and solving for S we obtain a theoretical value, $S = 0.25$ for pure shear flow.

Actual values of S may be expected to deviate from this value with surface roughness and with velocity for the reasons mentioned above, and a convenient plot should be S versus slope Reynolds number, with lines for various pipe roughnesses. In very small pipes the ratio of fiber length to pipe diameter may exert an additional influence.

In Fig. 3 is presented an illustration of this type of plot. Values of yield stress, s, are not actually known, nor are the fiber lengths, for the data presented. The author has made the rabid assumptions that the fiber lengths for sulphite and groundwood which existed in the Fulton tests would be correct for both the Guenter and Ceaglske data (*1*) and the Hydraulic Institute data (*2*) and that yield stresses using these fiber lengths together with equation (4) would apply. The results show that a single curve of S versus R will suffice, at least for a given fiber length, in spite of consistency variations of 2 to 6% and pipe diameter variations of 6 to 12 inches, with a probable error (envelope of 50% of the points) of ±15%. The coincidence of the value of S for sulphite in cast iron pipe at high Reynolds number with the theoretical value of 0.25 suggests that the sulphite stock used in the Hydraulic Institute tests did have a fiber length close to 0.2 inch as assumed. The deviation between groundwood and sulphite probably reflects merely the fact that the fiber length of Hydraulic Institute's groundwood was much greater than the 0.04-inch value assumed. The 2.4 exponent of consistency in equation (4), resulting from the shear tester data at Fulton, is excellently confirmed. The very high values of S shown for mirror-smooth copper pipe may also show merely an error in assumed fiber length, or it may reflect pressure drops truly lower than those for shear flow as a result of a water film formation at the smooth pipe surface. The flatness of the curves of S versus R at high Reynolds numbers confirms the calming influence of the presence of fiber and the ultimate validity of the shear theory of flow, but final values of S must await further tests in which laboratory determination of yield stress, s, and records of fiber length, j, accompany the flow and pressure loss data. If a turbulence effect does develop at still higher Reynolds numbers, the single curve may be expected to branch, requiring a parameter comparable to the Fanning friction factor, f. A more convenient turbulence-shear parameter, the product Sf, from which pressure drop cancels out, and in which ρ is the mass density of the flowing material, would be simpler to use.

$$T = \frac{s}{\rho V^2} \qquad (7)$$

Numerical values of T may be used to identify branching lines on the S-R diagram should they be found necessary, though it appears that a turbulence influence is not likely to develop until Reynolds numbers of several million are encountered, except in very low consistency stock streams.

If S were truly constant in pipe flow, the pressure loss versus flow curves would be horizontal lines. The droop in pressure drop actually observed implies that the actual and apparent yield stresses are not equal, that in some cases an actual yield stress does not exist. Such shear diagrams are common enough and "pseudoplastics" and other types of non-Newtonian fluids may be expected to yield data differing significantly from the shear theory at extremely low shear rates. Such anomalies may be written off as of little industrial concern at the moment, while of definite academic interest.

SHEAR FLOW IN PUMPS, VALVES, FLOWMETERS

The calming influence of fibrous solids which we have observed to prevent turbulence up to R = 1,000,000 in pipe flow will be largely destroyed in flow through abrupt transitions such as pump passages, valves, and inferential flowmeters. This is obviously desirable since the type of shear flow which occurs in pipes would inhibit vortex and jet formation, and render such devices inoperative.

The determination of external losses imposed by a pipe system discussed above, is of major concern in pump selection. The shear criterion, $s/\Delta P$, where ΔP is the pressure rise developed by the pump, will be of use in defining the region of possible pump operation rather than in characterizing the operation in this region. In other words, a series of pumps of geometrically similar design may be expected to develop a slurry plug in impeller passages and stop working at comparable values of S, in combination with comparable values of the true-fluid pump criteria.

A variable head flowmeter may be expected to "stop working" as soon as pure shear flow exists. That is, a pressure drop dependent largely on the flow geometry and the yield stress may be expected to remain nearly constant over a wide range of flows, and so fail to measure flow itself at all. The worst case would, of course, be a length of pipe. We progress toward possible flow metering as we go to an ever sharper transition in flow geometry, from the worst case, a straight pipe, through intermediate primary elements such as venturis, nozzles, and rounded-approach orifices, to a best possibility in the form of a flat-plate, sharp-edged orifice. Considering all of these devices merely as pipes of various lengths, equation (5) shows how a decrease in pressure drop due to shear occurs as the length, L, decreases. The sharp-edged orifice is almost equivalent to $L = 0$, so that the pressure loss due to shear will be minimized, and the actual pressure drop approaches that which is associated with the Bernoulli equation, making flow metering possible. Shear effects are never completely eliminated, however, and the useful range of the variable-head meter will be limited, as the differential decreases toward a value at which shear stresses will again be appreciable.

The variable-area flowmeter overcomes this difficulty because it operates over a wide range of flows without change in pressure drop, as discussed below. However, those considerations regarding the shape of the flow passage which were discussed above apply to the shape of the "float" (Fig. 4) employed. The author's company has been through the cycle, presupposing that a streamlined or tear-drop shaped float would somehow be superior in slurry service to the sharp, square-edged float that has proved its superiority through the years in the flow of both viscous and compressible true fluids. The presumption is wrong. Many streamlined floats are giving excellent service on paper stock streams at very high rates of flow, or at low consistencies. Nevertheless, there has been one

instance after another where a combination of low flow and high consistency has limited the useful range of a tear-drop float to the upper 50% of scale, where replacement with a sharp-edged float has provided satisfactory flow metering throughout the full meter range. There are three hydraulic reasons for this superiority. First is the maximum reduction of effective length, L, described above. The second is that the return to the Bernoulli-type flow is accompanied, in the case of the square edge, by the appearance of an annular *vena contracta*, so that the actual area between metering tube and float edge is large compared to the effective jet area. The third is the increase in float weight, pressure drop, and hence the ability to overcome shear resistance, which the formation of the *vena contracta* permits for a given flow range in a given meter size.

Similar reasoning applies to valve design for slurry service. Sharp-edged sliding gate valves should be less affected by the shear properties of fibrous slurry than any type of valve employing gradual transitions or elongated restrictions. The persistent superstition that fibers can somehow "hang" on a sharp edge must be abandoned in the face of experience.

VARIABLE-AREA FLOWMETER PARAMETERS

The variable-area flowmeter employs a float of weight, W_f, and density, ρ_f, which is buoyed by the flowing fluid of density, ρ, to yield a net downward force, F, Fig. 4. The buoyancy correction provides that.

$$F = \frac{W_f(\rho_f - \rho)}{\rho_f} \text{ grams} \qquad (8)$$

The float is free to move vertically upward within the limits provided by the stops, and the enlarged sharp-edged float head, having diameter D_f, inches, forms the inner periphery of the flow annulus. The outer periphery of the flow annulus is formed by the tapered variable-area metering tube. Since the differential pressure, ΔP, across the annular orifice between float and tube is fixed by F and D_f as:

$$\Delta P = \frac{4F}{453.6\pi D_f^2} = \frac{F}{356 D_f^2} \qquad (9)$$

it follows that the float elevation varies with the flow in such a fashion that the available area for flow is consistent with the annular jet velocity associated with this pressure drop in the Bernoulli equation. Algebraic simplicity is achieved by resorting to the simplest equations to be achieved from dimensional analysis. Recognizing viscosity (or slope viscosity), μ, gas elasticity, e, the apparent yield stress of non-Newtonian fluids, s, and particle size, j, as additional variables characterizing the flow and the local diameter of the tube, D_t, in the plane of the sharp float edge as the significant numerical measure of float elevation, we have a functional expression for volumetric flow rate, Q: Q depends on (F, D_t, D_f, float shape, ρ, μ, e, s).

The number of parameters is reduced by three by means of dimensional analysis, giving:

$$\frac{Q}{D_f\sqrt{F/\rho}} = f\left(\frac{D_f}{D_t}, \frac{\mu}{\sqrt{F\rho}}, \frac{F}{D_f^2 e}, \frac{sD_f^2}{F}, \frac{j}{D_f}, \text{float shape}\right)$$

That is to say, our basic equation becomes:

$$Q = KD_f\sqrt{F/\rho} \qquad (10)$$

where K depends on D_t/D_f or scale reading, and on

$$\text{viscosity criterion, } N = \frac{\mu}{\sqrt{F\rho}}$$

$$\text{elasticity criterion, } E = \frac{\Delta P}{e}$$

$$\text{shear criterion, } S = \frac{s}{\Delta P}$$

$$\text{particle size criterion, } \frac{j}{D_f}$$

When Q is expressed in cubic centimeters per minute, D_f in inches, F in grams, and ρ in grams per cubic centimeter, the convenient values of K used in area meter calculations are obtained. We will adhere to these convenient units, recognizing that a different set of numerical values of K would have been used, applicable to any set of consistent units, had we expressed D_f in centimeters instead of inches and F in dynes instead of grams.

The above dependence of K on N, E, S, and j/D_f covers many types of fluids, and in practice one or two of these influences predominate, and considerable simplification is possible in the correlation of paper stock flow coefficients. The high values of yield stress and low values of slope viscosity and the absence of compressibility permit us to employ S as the basic correlation parameter. When the ratio j/D_f is high, the values of the flow coefficient droop suddenly to zero. This droop occurs close to the lower end of the meter scale at a particular value of S, and at ever increasing scale readings as the value of S is increased. Thus, for a particular meter and fiber length, the borderline between meterable and nonmeterable flow rates is defined by an almost constant ratio of S to K. Further, it may be inferred that this borderline value of S/K will vary inversely with j/D_f, that is, at constant yield stress in a particular meter, a doubling of the fiber length will double the scale reading at which meterability will be lost. We may modify equation (10) by a "droop factor," B, such that: B = a function of $(j/D_f)^a$ $(K)^b(S)^c$. Since all quantities in this equation are dimensionless, physical reasoning alone cannot define the exponents a, b, c but experimental observations lead to: $a = 1$, $b = -1$, $c = 1$, so that B = an experimental function of a particle size parameter, J, of the form:

$$J = 10^6 \frac{jS}{D_f K} \qquad (11)$$

where 10^6 is introduced to avoid unwieldy decimal point locations. Our basic equation for slurry flow then becomes:

$$Q = KBD_f\sqrt{F/\rho} \text{ cc. per min.} \qquad (12)$$

where K = a function of S and B = a function of J.

These functions are presented in Fig. 5. Their experimental background includes (1) several hundred water calibrations of meters employing floats geometrically similar in square-edge shape to that of Fig. 4, conducted between 1945 and 1950 at the hydraulics

laboratory of the author's company and at the hydraulics laboratory of the University of Pennsylvania under the able direction of Prof. W. S. Pardoe. The average of these tests dictates the limits of the values of K when S and J are both zero and when N is low; (2) tests conducted at various paper and paper machine companies under actual stock flow conditions, 1949 to 1951, notably those at Dilts Machine Works in Fulton, N. Y., herein referred to as the Fulton tests, in which both s and j were experimentally determined; (3) numerous instances where the "pillow" effect has been observed and corrected. This effect is the visual observation that a flowmeter becomes inoperative when flow rates are reduced below a certain value, indicating that the shear forces provided by the float were incapable of overcoming the yield stress of the stock, so that the float may be described as resting on a slowly moving "pillow" of the stock. Every case of the "pillow" effect has occurred at a value of J of 1.65 or higher, confirming that the B versus J plot of Fig. 5 is valid or conservative. This effect has been eliminated by reducing the meter size and increasing the float weight until the value of J at minimum scale reading has been reduced to well below the 1.65 value. Occasionally, at rates of flow well below 100 g.p.m. and at consistencies of 5% and more, it has been necessary to limit the range of the meter because the physical limit of float weight increase and size reduction has been reached. Long-fiber streams at much below 20 g.p.m. approach the impossible.

That value of flow at which the "pillow" effect develops, and below which the sensitivity is lost, is referred to as the "rock bottom" flow rate. A formula for estimating its value is an important flowmeter design guide. Such a formula may be written in terms of consistency, X, fiber length, j, float diameter, D_f, and float weight, W_f by combining equations (12), (11), and (4), and substituting $B = 0.5$, $J = 1.65$ and by assuming that the buoyed float weight, F, will be $^7/_8$ actual weight, which is approximately correct for most float metals, having densities close to 8 grams per cc. The resulting equation is:

$$\text{Rock bottom g.p.m.} = 17.4 \frac{D_f{}^2 j^{0.59} X^{2.4}}{\sqrt{W_f}}$$

A margin of assurance of 50% should be used where possible not only to allow for the 10 or 15% errors which may be incurred in the empirical equation (4) but also to allow for momentary variations in consistency above that specified. A rate of flow of 1.5

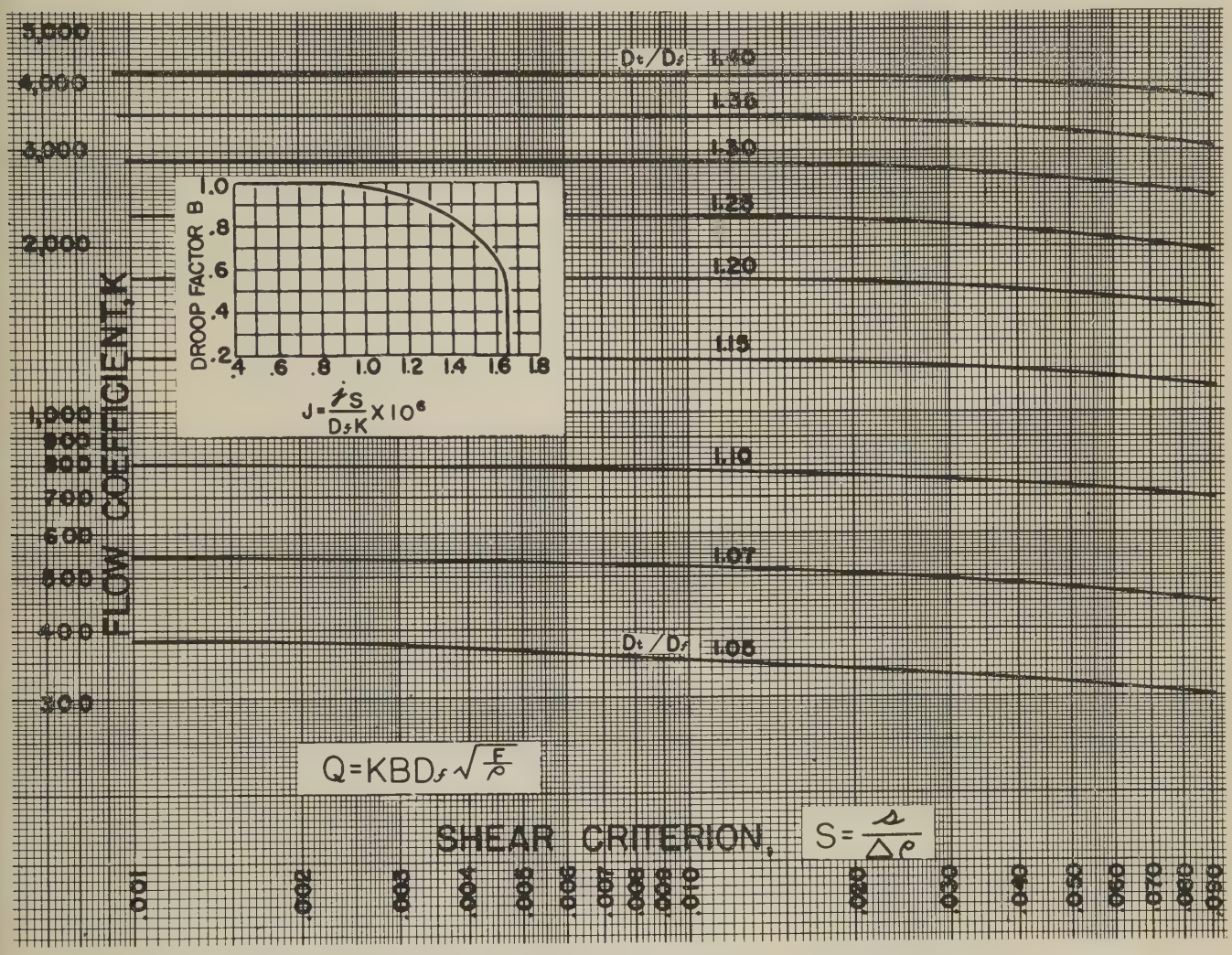

Fig. 5

times the rock-bottom value is called the "borderline" flow rate for the particular meter and stock stream. The author's company uses the borderline value as a design criterion.

FULTON TESTS

Volumetric flow tests were conducted using a 4.68-inch diameter float weighing 19,000 grams and having a density of 7.92 grams per cc. The tube provided diameter ratios from 1.05 to 1.4 and the meter was rated for 65 to 650 g.p.m. water.

Moisture-free consistencies were measured at least twice in the course of each calibration. If they failed to agree within 0.1%, a third sample was tested. Weyerhaeuser bleached sulphite was pulped to 7.2 consistency, the highest available with the laboratory pulping equipment. Pump and piping combination imposed a limit of about 550 g.p.m. at this consistency. It was necessary to rake the surface of the stock flat continuously to obtain a semblance of accuracy in volume measurement. This fact explains the 3% point scatter of the 7.2% sulphite data. The lower consistencies were then obtained by successive dilution. The actual test points for the five sulphite consistencies and for water are given in Fig. 6. The lines on this graph are not intended to represent the data, but are the results of calculations employing the procedures of the previous section. The dashed line crossing the calibration curves shows the variations in "borderline flow" with sulphite consistency.

One test was conducted with groundwood at the highest pulpable consistency which turned out to be 4.33% moisture-free. While this may have been reduced somewhat from the actual pulper consistency

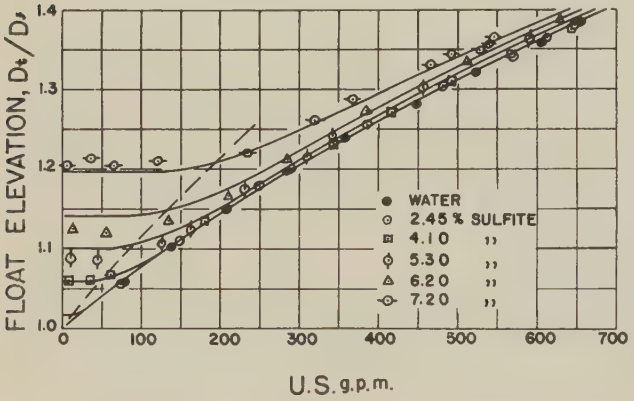

Fig. 6. Calculated and actual flow curves with variable yield stress

because of residual water in pipe and pump left after the water calibration, comparative performance of the laboratory pulper bears out the results of the shear tester that shorter fibers at a given consistency make for a higher apparent yield stress, s. In the absence of the present analysis, an attempt was made to predict the groundwood calibration on the basis of yield stress alone, by interpolating the sulphite data. The results are shown in Fig. 7, the upper curve labeled j/D_f = 0 041 being the interpolated sulphite curve for the value of s of the 4.33% groundwood, lying approximately midway between the curves for 5.3 and 6.2% sulphite given on Fig. 6. The excellent agreement between this curve and the data down to 30% of the meter's maximum flow was gratifying, but the lack of droop and the achievement of excellent meterability all the way to the minimum scale reading, D_t/D_f = 1.05, came as a surprise at the time. Subsequent data and development of the theory made possible the correct calculation for the actual value of j/D_f = 0.0082, the lower curve of Fig. 7, which shows excellent agreement with the tests throughout the meter range.

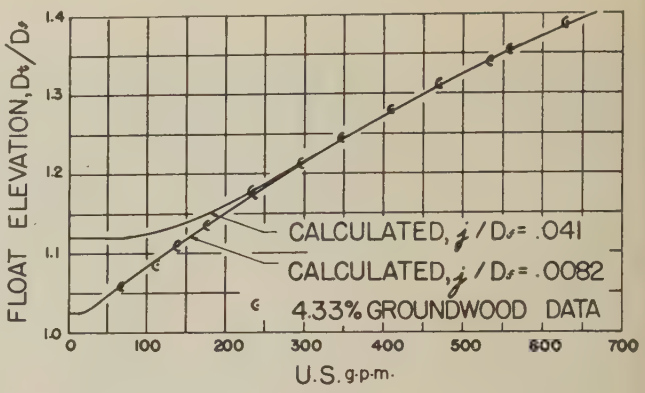

Fig. 7. Calculated and actual flow curves: influence of fiber length

All of the Fulton tests were conducted with manual throttling with a thin knife-edged gate valve. Similar valves were employed as shut-offs for switching the stock back to the supply tank. There was not a single instance of valve or meter plugging during the entire week of tests.

CONCLUSIONS

Accurate knowledge of the yield stress of a paper stock slurry should permit rapid estimates of pipe friction losses which are essentially independent of velocity. Further laboratory testing of pipe friction is recommended, employing a continuously rotating shear tester with provisions for torque measurement at steady rotational speed, together with fiber length and consistency observations, as an adjunct to the pipe friction measurements. The importance of freeness should not appear directly, but may be helpful in future estimates of yield stress. It is probable that shear and fiber-length criteria, upon proper observation of these properties of the stock, may be as successfully applied to valve, orifice, and nozzle performance as to the performance correlations of the variable-area flowmeter. It is to be hoped that the complex and often fruitless use of apparent viscosity or other substitutes for viscosity may be replaced by the two separate fluid properties, slope viscosity and apparent yield stress, in non-Newtonian fluid mechanics.

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Some Molecular Properties of the Hemicelluloses of Black Spruce

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Representative samples of hemicelluloses isolated from black spruce have been studied with respect to the molecular size and chemical homogeneity. Methods of preparing holocellulose were examined to determine their relative influence on the D.P. of the hemicelluloses. Based on viscosity measurements, the hemicelluloses isolated from a holocellulose prepared by a chlorine-ethanolamine procedure were found to be less degraded than those from holocelluloses prepared by the chlorite or chlorine dioxide-pyridine procedures. Therefore, hemicelluloses for further study were prepared by this method. The benzoate, benzoate-acetate, and butyrate esters of the hemicelluloses were substantially soluble in certain organic solvents. The butyrate was most suitable for molecular weight measurements, for it was formed with least reduction of D.P. and with the highest yield of chloroform-soluble products. Formation of films of these derivatives was also shown to be possible. The average molecular weight of the isolated hemicelluloses, determined by osmotic pressure measurements on the derivatives, was approximately 20,000. This corresponds to a D.P. of 150 (calculated as a pentosan) or 120 (calculated as a hexosan). Chemical heterogeneity of the hemicelluloses was established by fractional precipitation from formamide solutions; the fractions isolated had pentosan contents ranging from 30 to 57%. Fractionation of the butyrate from acetone solutions yielded fractions which had D.P.'s ranging from 50 to 300.

THE term *hemicelluloses* was introduced by Schulze (*1*) to denote the alkali-soluble polysaccharides of wood and of other plant tissues. Other workers have since used this term to denote the noncellulosic carbohydrates of wood. Although these definitions are not identical, they do include approximately the same classes of compounds.

Interest in the hemicelluloses has centered mainly on their chemical composition and structure, but their influences on pulp properties have also attracted considerable attention. A review of the chemistry of the hemicelluloses has been presented by Wise (*2*) and Cottrall (*3*) has discussed the effects of the hemicelluloses on the papermaking properties of wood pulps.

Our present knowledge of the physical properties of the hemicelluloses is very limited. This is apparent from both reviews mentioned above. This knowledge must be increased markedly before the hemicelluloses can be most efficiently utilized. One obvious gap in our present knowledge relates to the molecular dimensions of the hemicelluloses. Wise (*2*) has suggested that Husemann's and Stamm's work on the molecular dimensions of the hemicelluloses should be extended—working with representative and undegraded samples.

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The major contribution to our knowledge of the molecular weights of the hemicelluloses has been made by Husemann (*4*), who studied hemicelluloses isolated from straw, beech, and spruce. The hemicelluloses from wheat straw and beech were isolated by alkaline extraction of the original materials, or of holocelluloses prepared according to the procedure of Schmidt, Tang, and Jandebeur (*5*). The spruce hemicelluloses were isolated only by the latter procedure.

To ascertain whether this substance (spruce hemicellulose) was a single polysaccharide or a mixture of two or more substances, Husemann (*4*) fractionated his spruce hemicelluloses by adding methyl alcohol to a solution of the hemicelluloses in 6% sodium hydroxide. Viscosity and optical rotation data on the fractions indicated little fractionation, although the methoxyl content increased in the later fractions. On the basis of these results, Husemann implied that the major portion of the spruce hemicellulose consisted of a single carbohydrate of uniform molecular weight. Wise and Ratliff (*6*) have obtained fractions of spruce hemicelluloses which varied widely in their mannan content. This evidence, which indicated that the hemicelluloses were not homogeneous, does not agree with Husemann's results.

Husemann (*4*) found that about 35% of the spruce hemicellulose was water soluble. He determined the molecular weight of this fraction by osmotic pressure measurements on it and on its benzoate-acetate derivative. A degree of polymerization (D.P.) of 160 (calculated as a hexosan) for these hemicelluloses was indicated.

Husemann found the average D.P. of the beech and straw hemicelluloses to be about 150. In the calculation of this D.P. it was assumed that the material was a xylan. From the results of fractionation of these hemicelluloses and their derivatives, he concluded that the molecular weights of these hemicelluloses were also quite uniform.

Millett and Stamm (*7*) studied the physical properties of the hemicelluloses of aspen obtained from a holocellulose prepared according to the procedure of Van Beckum and Ritter (*8*). An average D.P. for these hemicelluloses of 80 was indicated by their results. This is in the same range of molecular weights as the average D.P. of 70 reported by Chanda, et al. (*9*) for a xylan from esparto grass.

The molecular weights reported by Husemann (*4*) are significantly larger than those reported by Millett and Stamm (*7*) or Chanda, et al. (*9*). This difference may be due to the disparate origins of the hemicelluloses; however, inequalities in the amounts of degradation during isolation may also have contributed to these differences. For example, the hemicelluloses

are very easily hydrolyzed; Yundt (*10*) reports that mild acid hydrolysis will hydrolyze part of the linkages in hemicelluloses and Thompson (*11*) found that heating in water at 80 to 110°C. degraded aspen hemicelluloses. Thus, as Millett and Stamm subjected their aspen hemicelluloses to hot water and acid during isolation, it is probable that the isolated products were degraded.

This study was undertaken to determine the average molecular weight of spruce hemicelluloses isolated with a minimum of degradation. An additional objective was to determine whether or not the composition and molecular weight of spruce hemicelluloses were uniform as implied by Husemann (*4*).

PREPARATION OF THE HEMICELLULLOSES

Hemicellulose fractions were obtained by alkaline extraction of holocelluloses prepared from black spruce wood meal. This wood meal was prepared from a freshly cut spruce log by converting the peeled log to sawdust, screening, reducing the oversize fraction in a Wiley mill, and rescreening. That portion which passed a 30-mesh screen and was retained on an 80-mesh screen was extracted with alcohol-benzene, and air dried.

A study was made of methods of preparing holocelluloses to provide a basis for the selection of a method which would yield hemicelluloses with minimum degradation. Yields and viscosities of alkaline solutions of the hemicelluloses were used as criteria for evaluation of these procedures. Three general types of holocellulose preparations were employed.

The chlorine dioxide-pyridine method of Schmidt, Tang, and Jandebeur (*5*) was one of the three methods. Using this method, a holocellulose was prepared by means of a 28-day treatment of the wood meal with the chlorine dioxide-pyridine solution at room temperature.

The chlorite method of Wise, Murphy, and D'Addieco (*12*) was also used to prepare holocelluloses. An investigation of the effects of temperature of chloriting and number of chlorite treatments indicated that three treatments of the wood meal with sodium chlorite at 70°C. caused less degradation of the hemicelluloses than did chloriting under any of the other conditions tested.

Van Beckum and Ritter's method (*8*) of preparing holocellulose (employing chlorine and an ethanolamine solution) has been modified by Thomas (*13*) to reduce degradation and losses during preparation of the holocellulose. In Thomas' modification the wood meal was chlorinated by bubbling chlorine into a suspension in cold carbon tetrachloride. In this study, the method of chlorination was further modified to reduce the time required for chlorination and to simplify the chlorinating operation. A solution of chlorine in carbon tetrachloride, which had been cooled to below 0°C., was mixed in a beaker with moist, water-washed, cold wood meal (0 to 5°C.). The resulting suspension, which was cooled in an ice-alcohol bath, was stirred continuously. At the end of each chlorination, after removing the carbon tetrachloride by filtering the suspension on a Buchner funnel, the chlorinated wood meal was washed twice with cold and twice with hot 3% ethanolamine solution in alcohol. The wood meal was suspended in hot ethanolamine solution (75°C.) for 2 minutes and then this solution was removed by means of suction. After giving the wood meal three extractions by this procedure, it was washed several times with alcohol. The wood meal was prepared for further chlorination by washing with a 1 : 1 water-ethyl alcohol solution. Variations involving the number of chlorinations, the duration of the chlorinations, and the temperature at which the chlorination proceeded were examined. The hemicelluloses from a holocellulose produced by five 5-minute chlorinations at 0°C. had the highest viscosity of those hemicelluloses isolated.

The same procedure was used throughout for extracting the hemicelluloses from the holocelluloses. The holocelluloses were extracted successively with 5 and 16% potassium hydroxide solutions for 2 hours at 20°C. under nitrogen to produce two fractions from each holocellulose. (The material extracted with 5% potassium hydroxide solution was designated as the "5% extract" and, similarly, the material extracted with 16% solution was designated as the "16% extract.") The hemicelluloses were recovered from the alkaline solution by pouring 1 volume of the solution into 4 volumes of alcohol containing enough acetic acid to neutralize the base used in extracting the hemicelluloses. The precipitated solid was recovered by centrifuging the suspension, and was washed with alcohol and ethyl ether and then air dried. The yields, which are expressed as grams of hemicellulose per 100 grams of oven-dry extractive-free wood, were determined by weighing the isolated hemicelluloses and are corrected for the moisture and sulphated ash as potassium.

Viscosity measurements on dilute solutions of the hemicelluloses were made at 30°C. with Ostwald-Fenske viscometers. The alkaline solutions of hemicellulose for viscosity measurements were prepared and stored under nitrogen until flow times were measured. Specific viscosities were calculated in the usual manner (*14*, *15*).

The specific viscosities of the 5 and 16% extracts dissolved in 9.6% potassium hydroxide solution were determined on solutions containing 0.5 gram of hemicellulose per 100 ml. of solution. The highest yields and viscosities of the hemicelluloses obtained from each type of holocellulose preparation are presented in Table I.

Table I. Yields and Viscosities of the Hemicelluloses

	A[a]	B[a]	C[a]
Yield, 5% extract	8.2	13.0	9.0
Yield, 16% extract	3.8	5.3	6.4
Total yield of hemicellulose	13.0	18.3	15.4
$\eta_{sp.}/c$, 5% extract	0.33	0.54	0.72
$\eta_{sp.}/c$, 16% extract	0.59	0.71	0.97

[a] Hemicelluloses isolated from a holocellulose prepared by: (a) the chlorine dioxide-pyridine procedure of Schmidt, Tang, and Jandebeur (*5*); (b) the chlorite procedure of Wise, Murphy, and D'Addieco (*14*); (c) the chlorine-ethanolamine procedure (a modified Thomas procedure) (*13*).

The yields of hemicelluloses varied from 13.0 to 18.3 grams per 100 grams of oven-dry, extractive-free wood. The low yield from the chlorine dioxide-pyridine holocellulose was caused by losses of hemicelluloses during the holocellulose preparation. Part of the difference in yields of isolated hemicelluloses from the chlorine-ethanolamine holocellulose and from the chlorite holocelluloses was caused by larger mechanical losses in the preparation of the former. However, a

more important cause appeared to be the retention in the alkali-insoluble residue from the chlorine-ethanolamine holocellulose of a portion of the material that was extracted from the chlorite holocellulose. The yield of this residue from the chlorine-ethanolamine holocellulose was larger by 2.7 grams per 100 grams of wood than it was from the chlorite holocellulose. Thus, this difference in yields of alkali-insoluble residues was approximately equal to the observed 2.9 grams per 100 grams of wood difference in yields of hemicelluloses.

The viscosities in alkaline solutions of the hemicelluloses isolated from the various holocelluloses varied more than did the yields, since the values of $\eta_{sp.}/c$ ranged from 0.33 to 0.97. Furthermore, the hemicelluloses isolated from the chlorine-ethanolamine holocellulose had the highest viscosities. It has been demonstrated that $\eta_{sp.}/c$ should be a comparative measure of molecular weight, if the measurements are made on a single solute-solvent system under standardized conditions (*14*, *15*). As the hemicelluloses were all isolated from spruce, and even though there were some variations in yields, the hemicelluloses isolated from the various holocelluloses should all be essentially the same material. Therefore, the solute was the same in all cases and the above relation should hold. On this basis, the conclusion was reached that the hemicelluloses isolated from the chlorine-ethanolamine holocellulose were less degraded in isolation than were those from the other holocelluloses. Accordingly, several batches of holocelluloses were prepared by using the chlorine-ethanolamine procedure, and the hemicelluloses from these holocelluloses were used for subsequent work.

PROPERTIES OF THE HEMICELLULOSES

The compositions of these hemicelluloses and of the wood meal were determined by standard methods of analysis, except that the mannan contents were determined by the procedure of Wise, Ratliff, and Browning (*16*). The analytical data obtained for these materials are presented in Table II.

Table II. Analysis of Hemicellulose and Wood[a]

	5% Extract	*16% Extract*	*Wood*
Mannan, %	7.7	22.2	8.5
Uronic anhydride, %	21.1	13.5	2.8
Pentosan, %	47.5	38.9	8.8
Sulphated ash, %	12.7	13.2	..
Insoluble ash, %	1.0	1.1	..
Lignin, %	[b]	[b]	29.7

[a] All values are on the moisture and ash-free basis, except for ash which is on a moisture-free basis.
[b] Klason lignin determination indicated a negligible amount of lignin in the hemicelluloses.

The total of mannan, uronic anhydride, and pentosans accounted for approximately 75% of the hemicelluloses. Paper partition chromatography of hydrolyzates of the hemicelluloses indicated that a considerable amount of glucose and/or galactose was present in addition to lesser amounts of unidentified sugars.

The specific viscosities of the two extracts dissolved in 10% potassium hydroxide solution were determined at various concentrations of the hemicelluloses; the data are presented graphically in Fig. 1. These data gave typical straight lines when $\eta_{sp.}/c$ was plotted versus concentration.

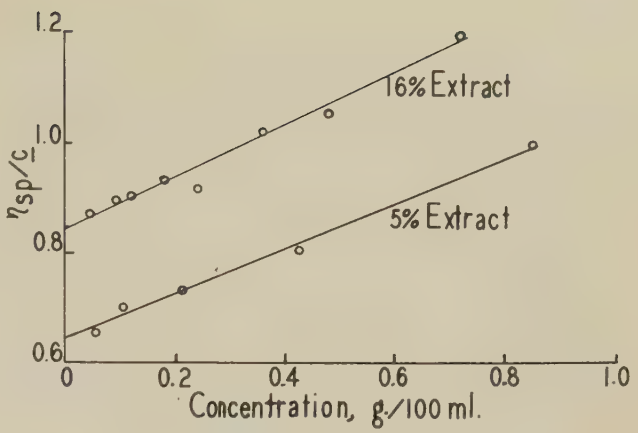

Fig. 1. Effect of concentration on viscosities of the hemicelluloses in 10% KOH

The effect of prolonged contact of the hemicelluloses with alkaline solutions was investigated. The hemicelluloses were dissolved in 10% potassium hydroxide solution and stored under nitrogen. After 1000 hours' contact with alkali, the value of $\eta_{sp.}/c$ of the 5% extract was reduced from 0.75 to 0.61 and that of the 16% extract was reduced from 0.97 to 0.67. Thus, alkali slowly degrades the hemicelluloses. Furthermore, qualitative tests on the combined effects of alkali and air indicated that the two degraded the hemicelluloses much more rapidly than did the alkali alone.

MOLECULAR WEIGHT OF THE HEMICELLULOSES

To determine the molecular weight of the hemicelluloses it was necessary to apply an absolute method of determining molecular weight; an osmotic pressure method was chosen for this purpose. The osmometers described by Zimm and Myerson (*17*) and the semistatic method of measuring molecular weight (*14*, *15*) were used. These measurements were made at a temperature of 30 ± 0.02°C.

To obtain solutions suitable for osmotic pressure measurements, it was necessary to convert the hemicelluloses to derivatives. A method similar to that described by Carson and Maclay (*18*) was used to prepare the butyrate ester of the hemicelluloses. The Schotten-Baumann reaction was used to prepare the benzoate; the ester was purified by decomposing the excess benzoyl chloride in moist pyridine and then repeatedly precipitating solutions of the benzoate into nonsolvents. In addition, the benzoate-acetate, a mixed ester of the hemicelluloses, was prepared by the procedure described by Husemann (*4*).

The acyl contents of the esters were determined by applying the alcoholic-alkali method of Genung and Mallatt (*19*). In the case of the benzoate-acetates, after determining the total acyl content of the esters, the benzoyl content of the liquors from the acyl determination was measured by an ultraviolet absorption technique (*20*) and the acetyl content determined by difference.

The properties of the butyrate, benzoate, and benzoate-acetate esters of the two extracts are presented in Table III.

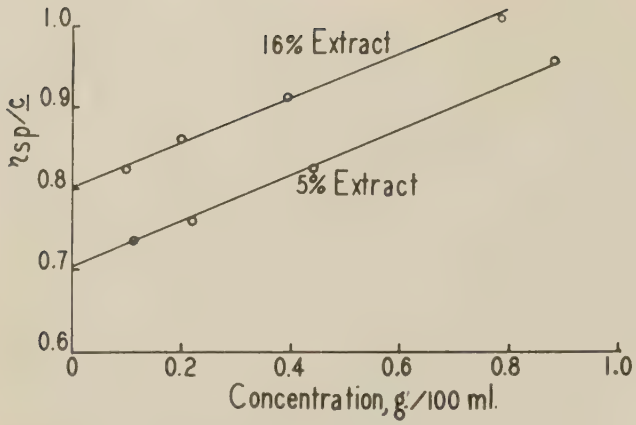

Fig. 2. Viscosities of the butyrates in chloroform

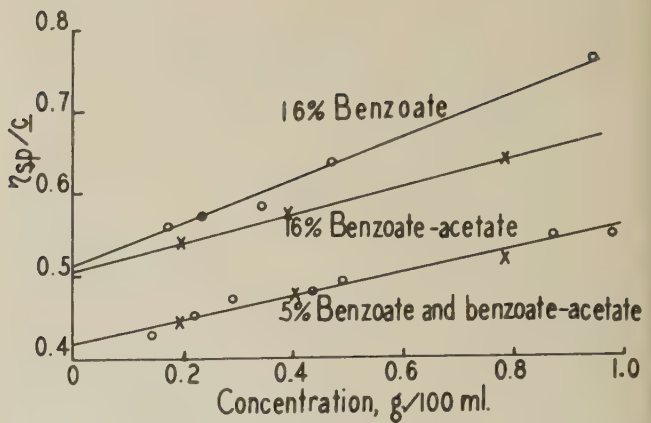

Fig. 3. Viscosities of the benzoates and benzoate-acetates in chloroform

Osmotic pressure measurements were made on dilute solutions of these derivatives in chloroform, and the molecular weights of the derivatives were calculated from the osmotic pressure data using van't Hoff's equation (*19*, *20*). The average molecular weight for the derivatives, obtained by measurements on each of the derivatives at a minimum of three concentrations, and the calculated average molecular weights and D.P's of the hemicelluloses are presented in Table IV.

Table III. Properties of Acyl Derivatives of Hemicellulose Fractions

	Benzoate		Benzoate-acetate		Butyrate	
	5%[a]	16%[b]	5%[a]	16%[b]	5%[a]	16%[b]
Benzoyl, %	56.4	55.9	57.9	55.2	..	..
Acetyl, %	..	..	2.4	6.4	..	..
Butyryl, %	..	..	..	..	54.2	55.1
Yield, %[c]	186	195	170	178	197	202
Theoretical yield, %[d]	230	227	252	260	218	223
Solubility, %[e]	91.5	94.2	..[g]	..[g]	97.5	67.8
D.S. pentosan[a, f]	1.60	1.57	1.98	2.29[h]	2.17[h]	2.25[h]
D.S. hexosan[b, f]	1.98	1.94	2.45	2.81	2.67	2.76

[a] Derivative from 5% extract.
[b] Derivative from 16% extract.
[c] Actual yield of ester, grams per 100 grams of the hemicellulose.
[d] Expected yield calculated from acyl content.
[e] Percentage of the ester which was soluble in chloroform.
[f] The degree of substitution calculated from the acyl content, assuming that it is (a) a pentosan and (b) a hexosan.
[g] The insoluble material was removed in purification.
[h] The highest possible degree of substitution for a pentosan is 2.00. Thus, these figures are impossible but are included for comparative purposes.

The average molecular weights of the spruce hemicelluloses indicated by osmotic pressure measurements on the derivatives ranged from 18,000 to 26,000. Those molecular weights obtained from measurements on the butyrates were probably closest to the true molecular weights of the hemicelluloses, for the over-all yields of chloroform-soluble products were higher than those from the other esterifications. In addition, the butyrates were less degraded in the acylation, as was shown by viscosity measurements on the original hemicelluloses and on the deacylated products from the butyrates and the benzoates. These products were deacylated by the procedure of Peterson, Barry, Unkauf, and Wise (*21*). The values of $\eta_{sp.}/c$ for the deacylated products from the butyrates were 95% of those of the original hemicelluloses, whereas those for the products from the benzoate were only 80% of the original values.

The viscosities of dilute solutions of the derivatives in chloroform were measured. The data on the butyrates are presented in Fig. 2 and those for the benzoate and benzoate-acetate esters are given in Fig. 3.

The plot of $\eta_{sp.}/c$ versus concentration gave typical straight lines for all three derivatives. There was no indication of association of the molecules in solution from either the viscosity or osmotic pressure data.

The molecular weights of the hemicelluloses were not as high as those of the cellulose normally used in making films of cellulose or cellulose derivatives. However, it was possible to form films from the derivatives of the hemicelluloses; the tensile strength of films of the butyrate, benzoate, and benzoate-acetate was approximately 5000 p.s.i.

Fractionations

Each of the two hemicellulose fractions (5% extract and 16% extract) was subjected to fractional precipitation from a formamide solution. The soluble portion of the hemicellulose was dissolved in the formamide, and the insoluble material which was removed by centrifuging was the first fraction. The next fraction was obtained by adding alcohol with very vigorous stirring until the solution became turbid. After standing 15 minutes at 30°C. and 2 hours or more at 20°C., the fraction was recovered by centrifuging, washed with alcohol, and then ethyl ether, and dried *in vacuo* at room temperature. Subsequent fractions were obtained by a similar procedure. The pentosan contents and viscosities of the fractions in

Table IV. Molecular Weights by Osmometry

	Benzoate		Benzoate-acetate		Butyrate	
	5%	16%	5%	16%	5%	16%
Molecular weight of the derivative	56,000	60,000	51,000	52,000	39,000	51,000
Molecular weight of the hemicellulose[a]	25,000	26,000	20,000	20,000	18,000	23,000
D.P. pentosan[b]	189	202	155	155	139	178
D.P. hexosan[c]	154	165	126	126	113	145

[a] Molecular weight of the hemicellulose calculated by multiplying the molecular weight of the ester by (100 − percentage of acyl content)/100.
[b] Calculated as a pentosan.
[c] Calculated as a hexosan.

Table V. Results of Fractionation of the Hemicelluloses

Fraction	Percentage of total	c^a	η_{sp}/c	Pentosans[b], %
		5% Extract		
Original[c]	..	0.43	0.81	53.8
1	8.9	0.42	0.75	..
2	19.5	0.46	0.73	42.7
3	45.4	0.46	0.93	51.3
4	14.7	0.43	0.69	57.4
5	5.8	0.52	0.16	..
Total	94.3			
		16% Extract		
Original[c]	..	0.47	1.03	42.7
1	42.2	0.32	0.94	29.8
2	5.1	0.32	0.89	..
3	3.6	0.29	0.90	..
4	7.8	0.40	1.11	..
5	34.3	0.57	1.16	54.4
6	1.6	0.43	0.49	..
Total	94.6			

[a] Concentration is in grams per 100 ml.
[b] Uncorrected for uronic acid.
[c] The unfractionated extract.

10% potassium hydroxide solution are presented in Table V.

Pentosan contents of the various fractions varied from 29.8 to 57.4%. The analyses of the two extracts had indicated that the hemicelluloses of spruce were not uniform in composition and these data further demonstrated this point. Therefore, the hemicelluloses of spruce must *not* consist of a single carbohydrate but, rather, must be composed of a mixture of materials.

Viscosity measurements on alkaline solutions of the fractions indicated little variation in molecular weight, except for the last fraction from both extracts. However, as the composition was not uniform, the effects of composition on the course of the fractionation may well have obscured the effects of possible variations in molecular weight.

The butyrate esters of the 5% and the 16% extracts were fractionally precipitated by the addition of petroleum ether to acetone solutions. Except for the differences in the solute-solvent system, the general procedure used was the same as that described above for fractionation of the hemicelluloses. The viscosities and osmotic pressures of dilute chloroform solutions of the fractions were measured; the results are given in Table VI.

Table VI. Results of Fractionation of the Butyrates

Fraction	Percentage of total	c^a	η_{sp}/c	$\pi \times 10^{3b}$	$(\pi/c) \times 10^3$	M.W.[c]
		Butyrate of 5% Extract				
1	5.0	..	..	...	...	....
2	14.0	0.74	1.65	1.95	2.63	95,000
3	10.5	0.72	1.35	2.10	2.91	85,000
4	14.0	0.72	1.34	2.28	3.17	79,000
5	12.5	0.96	0.86	4.36	4.54	54,000
6	11.0	0.94	0.66	4.99	5.31	47,000
7	6.0	0.85	0.42	6.03	7.1	35,000
8	12.5	0.75	0.39	13.0	17.4	14,000
Total	85.5					
		Butyrate of 16% Extract				
1	42.5	..	..	...	...	....
2	1.5	..	..	...	...	....
3	29.0	0.74	1.32	2.82	3.81	65,000
4	5.0	0.88	0.96	4.37	4.96	50,000
5	5.0	0.81	0.64	3.84	4.74	52,000
6	3.0	0.54	0.57	2.90	5.38	46,000
7	7.5	0.75	0.49	5.98	7.98	31,000
Total	93.5					

[a] Concentration in grams per 100 ml.
[b] Osmotic pressure in atmospheres.
[c] Molecular weight of the ester calculated from osmotic pressure data.

The fractionations of the butyrates clearly demonstrated that the molecular weights of the isolated hemicelluloses of spruce were not uniform, and that the molecular weight range was quite broad was shown by both osmotic pressure and viscosity results. More specifically, the average D.P., calculated as a pentosan, ranged from over 300 to less than 50 for the fractions obtained. The observed variation in molecular weight must have been present in the unesterified hemicellulose, for it was possible to butyrylate the hemicelluloses and then deacylate the ester and recover the hemicelluloses without causing any large change in the viscosity of the hemicelluloses.

The results of the fractionations of the hemicelluloses and of the butyrate are not contradictory. In the former, fractionation was mainly according to composition whereas, in the latter, fractionation according to molecular weight occurred. If the fractionations had been carried out under different conditions and/or if more fractions had been obtained, it is probable that fractionation of either the hemicelluloses or their butyrates would have revealed both the variations in molecular weight and in composition.

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Pick Testing of Offset Papers

GORDON C. WHEELER and ROBERT F. REED

The printing impression and the factors that contribute to picking of paper during printing are discussed. The press conditions that should be simulated in a pick test are printing surface, ink-film thickness, pressure, period of contact, and rate of separation of printing surface and paper. A simple pick tester has been constructed that approximately meets these conditions. It consists of an unbalanced flywheel that acts as a pendulum, causing a spring-loaded, inked hammer to strike the paper sample. A series of eight tack-tested inks is used, and the pressure, period of contact, and rate of separation are adjusted to give the same results as an offset press at normal printing speed.

During recent years there has been much interest in the development of equipment and methods for measuring the pick resistance or surface bond strength of printing papers. Probably the best known and most widely used is the wax test, the shortcomings of which are generally recognized. All other tests are based on instruments that apply a medium of known tack (an ink or viscous liquid) to the paper surface in a manner simulating letterpress printing.

Two general methods have been proposed. In one, the same ink is applied to two paper samples simultaneously, and either the speed or the ink tack is increased until one of the samples is picked. This method yields comparative results only. All other methods depend on accurate control of viscosity of the liquid or tack of the ink used, thickness of film applied, and rate of its application to the paper. These methods are designed to yield numerical values of pick resistance. Obviously, the control of temperature and relative humidity is essential. Some of these methods involve a series of tests at different speeds using one or more inks. Others involve a single ink or viscous liquid and a speed that is constantly accelerating during the application. By calibration the speed corresponding to the point on the paper sample where pick starts gives its pick resistance.

Data obtained by the authors indicated some lack of correlation of pick-resistance measurements with offset press experience when the test method applied ink to paper by means of an unyielding metal surface. Also, the testing equipment available seemed unduly expensive, particularly for use by the offset printer. A study was therefore made as a result of which a new type of pick tester was built and tested. Preliminary results appear to be satisfactory.

NATURE OF THE PRINTING IMPRESSION

When paper is printed on a cylinder press, it is brought into contact with the inked form or offset blanket and then separated from it. The duration of contact and rate of separation depend on the geometry of impression and press speed. Figure 1 shows the printing impression diagrammatically. On modern offset presses the impression period *ac* is usually between 3×10^{-3} and 5×10^{-3} second.

Duration of contact between the paper and the inked form or blanket, however, is somewhat longer than this and is represented by *ad*. At a given press speed the distance *ad* will vary with the stretch or slack in the paper *de* already printed, which is, of course, partly dependent on the tack of the ink. *ad* is longest, of course, when a solid is being printed. If the printing is done by offset, the distance *ad* may be slightly increased by stretching of the blanket's surface rubber.

The velocity V, or rate at which the paper is separated from the printing form, depends both on the speed of the press v and on the distance *bd* from the plane of the cylinder axes. Force in the direction of V is necessary to rupture the ink film and is applied through the paper by means of the grippers *e*. The amount of this force depends on the ink tack, or resistance of the ink film to splitting, at the velocity V.

The tension applied by the grippers *e* to separate the paper from the form or blanket causes the paper to stretch, increasing the distance *bd* and thus the rate of ink film rupture. On web-fed presses there are no grippers and the web tension and stretch can be maintained constant. But on sheet-fed presses stretch of paper is a factor since the elongation increases as the distance *de* becomes greater. Stretch is also greater in printing sheet paper because printing is usually across the grain, the direction of greater stretch. Thus the rate of ink-film rupture V accelerates from front to back of the sheet resulting in an increasing tendency to pick or rupture the sheet toward the back edge.

Another factor is that, on many rotary presses, the front edge of the sheet is transferred to delivery or transfer-cylinder grippers that travel somewhat slower than the impression surface. This transfer often takes place when only about half the sheet has been printed. The result is to introduce slack in the sheet and still further increase the distance *bd*, the rate of ink-film rupture V, and the tendency to pick or split the paper. The effect of this slack in aggravating picking toward the back edge of the sheet is probably much greater than that of the paper stretch.

Still another factor is the transfer cylinder construction with spaced spider wheels between which the paper can sag. Any such sagging introduces still more slack in the printed part of the sheet and further aggravates picking toward the back edge.

In offset printing the rubber blanket is compressible. Any increase in printing pressure, therefore, lengthens the impression period *ac* and also the contact period *ad*. This increases the velocity V and the picking tendency. This is generally known to offset pressmen.

When the paper is separated from the printing surface, the effect is to apply tension normal to the paper

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surface at point *d*. It must therefore expand or stretch in thickness and, being elastic, must absorb energy so that the rate of ink film deformation at the separation velocity *V* is decreased. This is illustrated in Fig. 2 for both letterpress and offset impression. The paper at point *a* is under pressure, but at point *b* it is under tension normal to its surface and its thickness is increased. Rates of deformation of blanket, ink, and paper are indicated vectorially for the offset impression in Fig. 3. The total separation velocity *V* is shown as the sum of the blanket, ink film, and paper deformation velocities. Therefore, within the practical range of printing speeds, the more the paper can be stretched normal to its surface, the smaller the ink film rupture force will be and thus the greater the pick resistance of the paper. In other words, of two papers having the same internal bond strength, the one that stretches more in thickness will have the greater pick resistance.

When the effect of energy absorption is understood, it explains why it is necessary in testing pick resistance of paper to simulate closely conditions that exist in the printing impression. Energy absorption may strongly affect the pick strength of paper at normal printing speeds and yet not affect its bond strength when measured under nearly static conditions.

THE NATURE OF PICKING

Picking of the paper surface occurs in different forms. In uncoated papers the most common form is blistering or lifting of the surface as a result of internal rupture. The occasional lifting of individual surface fibers is called linting and must be distinguished from true picking.

In the case of coated papers the most common form of picking is also internal or base-stock rupture. Another less common form is coating pick, in which the coating is separated from the base stock without rupturing the fibrous structure. Still another form is "snapping-out" or picking along a narrow line at the back edge of printed solids. This is apparently due to a high localized stress due to an increased rate of separation of the paper from the inked form or blanket.

Picking stresses are greater in offset than in letterpress printing, principally because of the thinner ink films and tackier inks used. But it appears also that the conformability of the rubber blanket surface to irregularities in paper surfaces also tends to increase

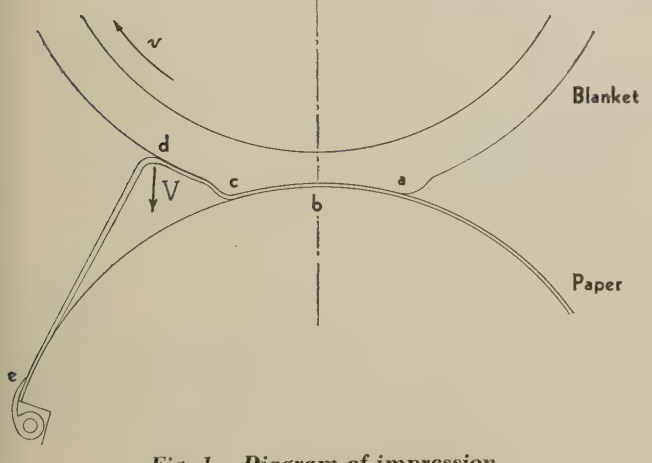

Fig. 1. Diagram of impression

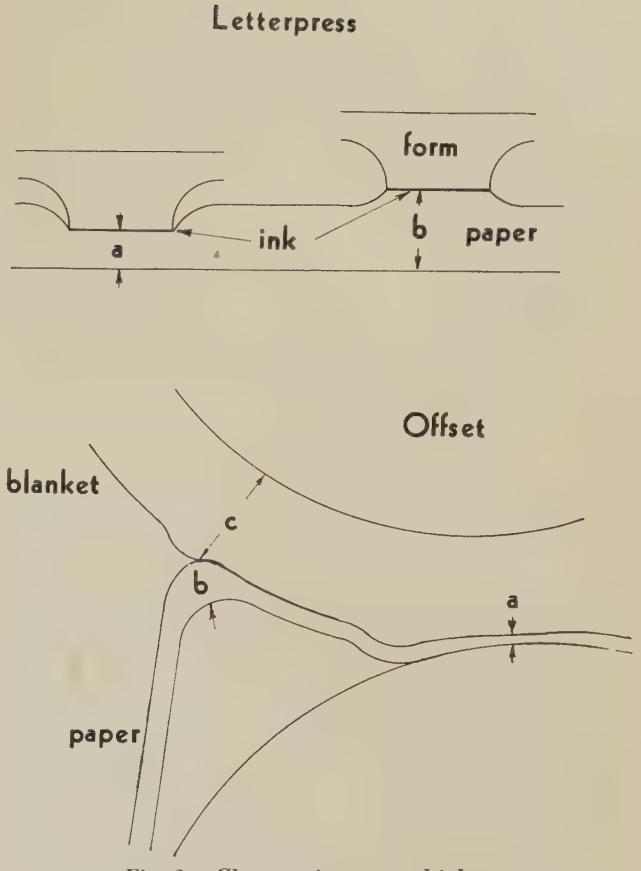

Fig. 2. Changes in paper thickness

picking stresses. This is evident because pick tests based on the letterpress principle do not always rate papers in the same order of pick resistance as tests based on the offset principle. Obviously, then, the latter type of pick test would be preferable for the testing and control of offset papers.

For maximum rupturing force, there must at least be complete ink coverage. Picking seldom occurs in halftones. Also, the area must be large relative to individual fiber length. In a testing method, this area should be as large as possible in view of variations over the paper surface. But there are practical limits and it is probable any area from $^1/_4$ to 1 square inch is sufficient. The ink-film thickness should be approximately that used in printing and should be accurately reproducible. And the pressure, duration of contact, and rate of separation should approximate normal conditions of printing.

DESIGN OF A PICK TESTER ON THE OFFSET PRINCIPLE

Given a series of inks of graduated, known tacks, an offset press could be used for testing the pick strength of paper. It would be an impractical instrument, however, in view of its high cost and the difficulties in controlling ink-film thickness, and the pressures in testing papers of different bulk.

With the exception of the wax test, all pick testers that have received publicity to date are based on the letterpress principle, and all simulate the action of a cylinder press. In other words, the ink or viscous liquid used is transferred from a rigid surface to the paper. The pick tester to be described, on the other hand, is an impact device operating on the offset prin-

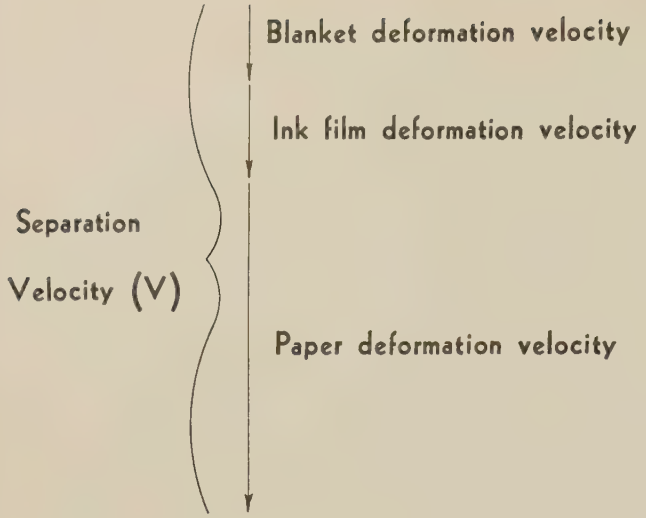

Fig. 3. Vector diagram of probable deformation velocities

ciple, with inks of known tack being transferred to the paper from a resilient offset blanket.

The design of the new pick tester is shown in Fig. 4. The flywheel A is unbalanced by weight C and the weight of the spring assembly. This unbalance provides impact velocity when the inked hammer D, which is covered with a piece of offset blanket, swings into contact with the paper sample E. On impact, the kinetic energy of the flywheel is stored in the spring causing it to rebound and carry the hammer back with it. The flywheel moment of inertia and unbalance, modulus of the spring and spring loading, and the distance allowed for the swing are calculated and adjusted to give the desired characteristics of pressure, period of contact, and rate of separation.

The approximate impression pressure needed was found by determining the pressure required to compress an offset blanket 0.003 to 0.004 inch, the normal printing pressure. The approximate period of contact needed and the rate at which the hammer surface should separate from the paper (rebound) were calculated from the geometry of the offset press impression (Fig. 1), disregarding the arc *cd* through which the paper adheres to the blanket.

A problem that had to be solved was the method of fastening the paper sample to the bed or anvil. When the sample was held to the anvil only at its edges, it was found that picking always started in a small area at the center. As the ink tack was increased, this area simply became larger. It was reasoned that the line of ink-film rupture started at the edges and traveled toward the center. Lateral stretching of the paper was thus reducing the ink-film splitting rate at all points except that of final separation, and confining first pick to a very small area. To obtain a uniform distribution of picking force over the entire test area, it was necessary to bond the paper sample to the entire area of the anvil. Two-sided, pressure-sensitive tape was found to do this satisfactorily.

Results so far with the new pick tester indicate that the shape of the hammer and anvil is not important. They can be either flat or cylindrical. In either case, the operating conditions can be adjusted to yield pick values that correlate with offset printing experience.

OPERATION

In making pick-strength determinations the series of eight IPI Tack Tested Inks is used. An ink drawdown is made on the recessed metering block with a scraper, as indicated in Fig. 5. This produces an ink film approximately 0.001 inch or 25 mu thick. The ink-metering block is shown at F in Fig. 4. The element that carries both it and the anvil is indexed to bring either of these into position to contact the hammer D.

To ink the hammer, turn the inked block into position and allow the hammer to swing against it four times. This transfers approximately a 0.0005-inch or 12.5 mu ink film to the hammer.

Stick the paper sample to the anvil with two-sided pressure-sensitive tape and turn it into the test position. Allow the flywheel to swing through the predetermined arc, so that the inked hammer contacts the paper sample and is pulled away by the rebound at the desired rate.

The tape and paper are then removed from the anvil and examined for indications of rupture or pick. Blistering or delamination is not always evident from the surface appearance so that it is advisable to cut across the inked area with a razor blade and examine the cross section. If there is no evidence of rupture, make another test using the next tackier ink in the series, and so on until rupture occurs. Report the paper as having the pick number of the ink that ruptures it, and note the type of picking produced.

Because of the known variation in paper bond strength at different points on the sheet area, it is not thought advisable to grade pick strength closer than can be done with the series of eight inks. This should be sufficient for practical purposes.

CORRELATION OF RESULTS WITH PRINTING EXPERIENCE

In order to correlate pick test results with results actually observed in offset printing, a press test was designed using the same series of Tack Tested Inks. A Harris 17 by 22 press was used with normal packing under the blanket, and the impression cylinder was set to give a 0.004-inch squeeze impression on 0.004-inch paper. The speed adjustment was set for 4000

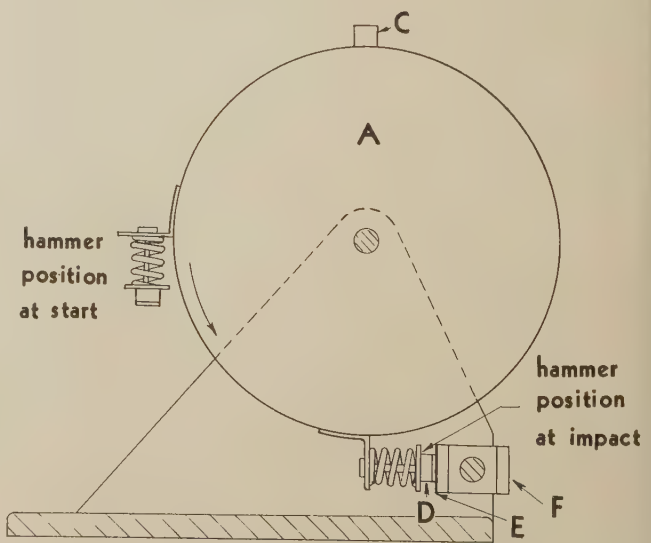

Fig. 4. Diagram of pick tester

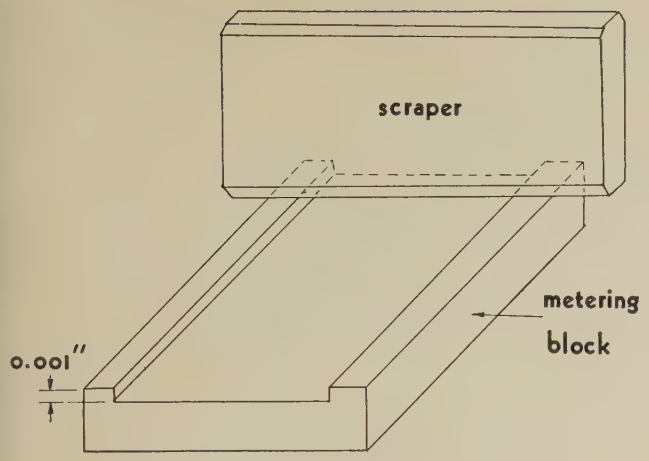

Fig. 5. Diagram of inking device

sheets per hour, corresponding to a linear speed of 166 f.p.m. The printing plate was omitted.

The series of Tack Tested Inks was applied to the blanket surface in a line near the back edge by making drawdowns on the ink-metering block (Fig. 5), and then rolling the block against the blanket to transfer an approximate 0.0005-inch ink film to it. When all eight inks were applied, the press was started, and at 4000 impressions per hour, a sheet was run through. The sheet was examined and given as its pick number the number of the least tacky ink that produced rupture. This was repeated with 24 different papers which were evaluated in the same way. The same sheets were then evaluated on the pick tester, and, where the result differed from the press result, the weight C (Fig. 4) that controls the rate of separation was adjusted until the same result was obtained.

It was found that, to give the same results as the press test, the rate of separation on the pick tester had to be increased from 1.2 inches per second (the calculated rate when no ink is present) to about 12 inches per second with ink no. 7. The explanation for this is that, on the press, the tendency of the paper to stretch and adhere to the blanket after the pressure is relieved increases with the tack of the ink, thereby increasing the effective rate of separation.

Table I. Comparison Between Pick Test Results

Press test	*L T F Pick Tester*	*Dennison wax no.*	*Pick tester using letterpress principle*
8[a]	8	13	..
8[a]	8	20	..
5	5	7	35
6	6	9	..
8[a]	6	11	..
6	6	10	..
6	6	8	..
6	6	9	25
5	3	7	25
6	6	8	35
5	5	8	20
5	6	10	..
6	6	6	35
5	5	8	..
6	6	6	..
4[a]	4	9	20
4	4	7	15
4	4	7	15
4[a]	4	7	..
4	4	9	20
4	4	7	30
4[a]	4	10	..
4	3	6	20
4	3	8	..
Correlation coefficients:			
All samples	0.89	0.63	
Coated paper[b]	0.86	0.23	0.68
Uncoated paper	0.63	0.67	

[a] Uncoated samples.
[b] Includes some coatings containing latex.

Table II. Energies Absorbed During Impact and Separation on the LTF Pick Tester

Energy absorbing elements	*Total rebound of flywheel*	*Energy absorbed in inch pounds/inch*[2a]
Blanket-covered hammer, no ink, nothing on steel anvil	27°	..
Ink no. 3 on blanket, nothing on steel anvil	21°	0.20
Ink no. 3 on blanket, pressure-sensitive tape on anvil	18½°	0.30
Ink no. 3 on blanket, tape and papers[b] sample on anvil	11½°	0.55
Tape alone, by difference	...	0.10
Paper[b] alone, by difference	...	0.25

[a] The energy values shown are first-order approximations, and only show approximate relationships.
[b] The paper sample was not ruptured during the test. Separation rate was 1.9 inches per second.

Having established the values for weight C for each ink from no. 1 to no. 7, the 24 papers were compared for pick resistance using the press test, the LTF Pick Tester, the Dennison wax test, and a pick tester based on the letterpress principle. The last-mentioned instrument determined pick resistance as a function of speed, and, with a single ink, it did not have sufficient range to test both the strongest and the weakest papers in the series. Only 12 of the papers gave results when tested on it. The papers included newsprint, offset, and coated-two-side. The coated papers included both latex and nonlatex coatings. Results are shown in Table I. All tests except those on the LFT Pick Tester were run at 58 ± 5% R. H. and 74 ± 5°F. Tests on the LTF Pick Tester were run at 33% R. H. and 75.5 ± 1°F. While this variation may affect the actual pick values, it is probable that the relative values are correct. Final evaluation of the LTF Pick Tester, however, should be made under TAPPI standard conditions.

For obvious reasons the offset press results were adopted as standard and correlations were based on them. The high correlation of the LTF Pick Tester results was expected because of the design features and the empirical adjustment of separation rates described.

DISCUSSION

The importance of using a separation rate in the pick test close to that occurring in printing is shown when the energies absorbed by ink and paper during the separation are measured. This was done by noting the arc of rebound of the flywheel and calculating the cor-

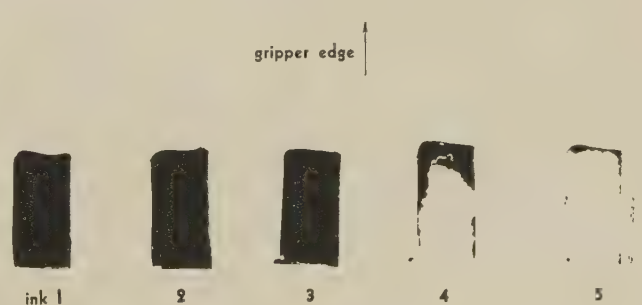

Fig. 6. Press test

responding energy absorption. The energies found are shown in Table II.

These energy absorptions will undoubtedly vary with the paper and the thickness of ink film used. A thinner ink film, such as is normally used in printing, should have a higher tack, but the effect of ink-film thickness on rupture energy has not been investigated. The energy absorption of the paper, however, should be even higher. Further studies of rupture energy are planned.

On the press a stiff paper will not follow the blanket as far as a flexible sheet will. The same is true in printing sheets in the grain direction as compared to printing in the cross direction, since paper is much stiffer in the grain direction. The LTF Pick Test makes no allowance for this variable. It is probable that, for the same printing speed, the pick test can be somewht lower for stiff papers and boards, and for paper to be printed in the grain direction as on a web press, than for flexible papers to be printed in the cross-grain direction.

Thickness of paper probably affects its picking tendency. The thicker the sheet, the more tension there is in the surface layer of fibers when it is bent around the impression cylinder in printing. This tension may aggravate picking. Its effect, if found to be important, can be compensated for by using a cylindrical anvil surface in the LTF Pick Tester.

The LTF Pick Tester is a very simple instrument having only one moving part. It is easy to operate and its cost should be relatively low. Such an instrument should satisfy the need in the print shop and also be suitable for control in paper manufacture. Probably any pick tester that simulates the printing operation would perform satisfactorily if the velocities and ink tacks are reasonably close to those that exist on the press.

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Kinetics of the Oxidation of Sulphate Black Liquor

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The process by which sulphate black liquor is oxidized by oxygen includes two distinct steps. The first step is the diffusion of oxygen through the air-liquid boundary, and the second step is the chemical reaction within the black liquor. The speed of the whole process will be set by the speed of the slower of these two steps.

If the black liquor is spread out in a thin film, that is, if it is given a large specific surface, the total transfer of oxygen through the boundary is very large and ultimately, for very large surfaces, the chemical reaction rate will be the controlling rate. For smaller surfaces the rate with which oxygen can enter the liquor is slower and may become the controlling rate.

The experiments described here were undertaken with the object of measuring the rate of oxygen absorption by sulphate black liquor when the area of the interface was very large, and the chemical reaction rate was the controlling process.

Black liquor oxidation has attracted a good deal of attention in the kraft industry recently. Some of the systems used commercially secure a large surface of contact between black liquor and air by a foaming operation followed by passage of the material through a foam breaker. The variable foaming tendency of black liquor from different wood species and the other operating variables make it difficult to predict in advance the effectiveness of a foam breaking system.

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If foam production can be avoided it is probably worth while to do so provided the oxidation can still be effected at a satisfactory speed.

These experiments suggest that the chemical resistance which controls the over-all rate when the surface is large is itself fairly large. It follows that nothing is gained by increasing the specific surface of the black liquor beyond a certain point, and therefore it is doubtful whether foam production is really necessary.

EXPERIMENTAL METHOD

The apparatus used is shown in Fig. 1. It was a modification of a type of respirometer used in studying tissue metabolism. Absorption of oxygen from the atmosphere in the 100-ml. jar, B, produced a drop in pressure which was then offset by pushing down the plunger of the graduated 5-ml. syringe, S, until equality of pressure on the two sides of the manometer, U, was restored. The 100-ml. jar, A, served as a compensator and prevented alterations in the bath temperature or barometric pressure from influencing the results. The black liquor or other oxidizable solution was injected into B with a 1-ml. hypodermic syringe and a blank (nonoxidizable) solution was introduced into the flask A by means of a second syringe. The liquids were absorbed, and a large surface area was formed when they fell onto thick pieces of filter paper or cellulose filter aid placed in the flasks.

The apparatus was fastened to a wooden support so that it could be removed from the constant temperature bath and the jars, syringes, etc., recharged. To pre-

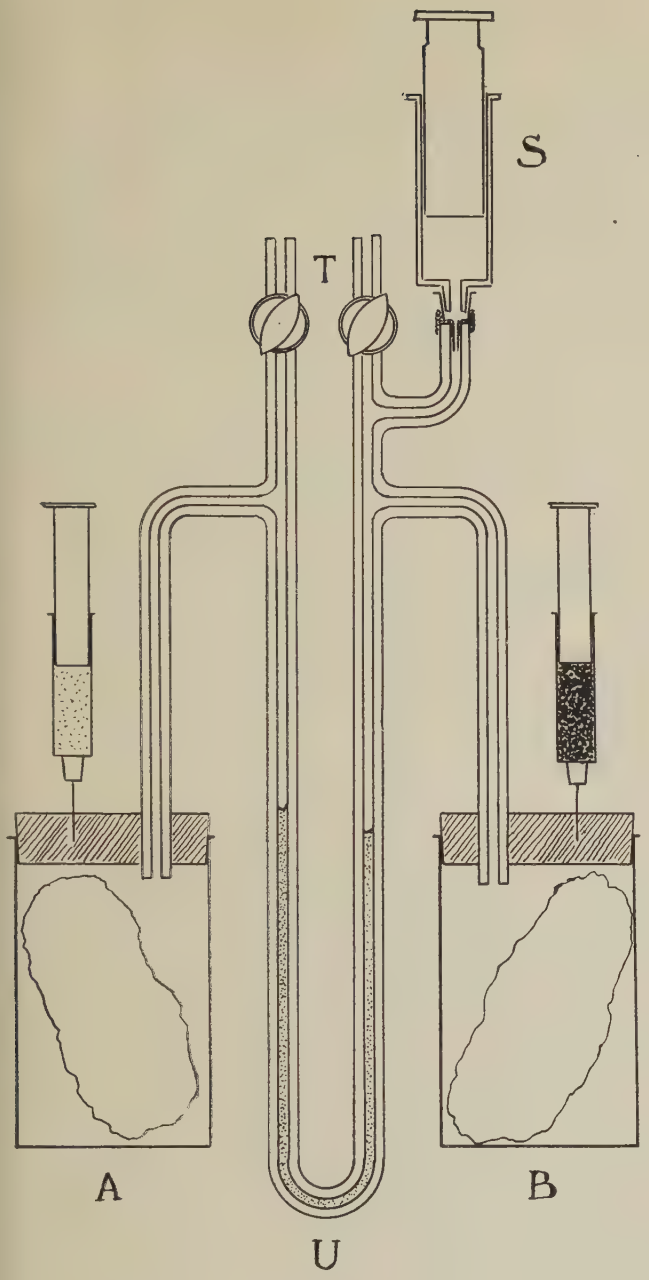

Fig. 1

pare for a run the jars were cleaned, and a piece of thick filter paper (cut from a Soxhlet thimble), or a square of dry cellulose filter pulp was placed in each. Two small fragments of the same paper moistened with water were placed in each jar to humidify the air when the jars were subsequently heated. The hypodermic syringes were then filled, respectively, with blank solution and black liquor and their needles were pushed into but not through the rubber stoppers. The jars were then attached and the apparatus was mounted on the side of a thermostat so that the jars and hypodermic syringes were immersed in the water.

It was generally necessary to allow 30 to 60 minutes for the jars to reach bath temperature and equilibrium to be established between the wet bits of paper and the water vapor in the jars. When a steady state had been reached it was possible to close the taps T for several minutes without the manometer U showing a pressure differential.

When such a steady state was attained, the syringe S was adjusted to a definite value, e.g., 4.0 ml., and the taps T were closed so as to isolate the two jars from each other and from the atmosphere.

The needle of the syringe in jar A was then pushed all the way through the stopper, the plunger was pushed home, and the syringe and needle were withdrawn. The process was then repeated with the second syringe containing the black liquor and a stop watch was started as the syringe was emptied. Thereafter the syringe S was manipulated to maintain equal pressures in A and B and the volume of gas absorbed by the black liquor, as indicated by syringe readings, was noted at intervals. The volume of oxygen absorbed was reduced to 0°C. and standard pressure. A thermometer was mountd beside the syringe S and the atmospheric pressure was measured with an aneroid barometer.

An irregular variation occurred at times in the first reading made after introducing the black liquor into the apparatus. This was probably due to pressure changes caused by evaporation or release of dissolved gases by the test solutions, and had the effect of introducing an uncertainty in the amount of oxygen taken up during the first 15 seconds of an experiment. In order to compare different runs the practice was adopted of adding or subtracting an arbitrary constant to all the volumes of each run to bring the curves into coincidence at a time of 15 seconds.

The apparatus was set up at the Bloedel, Stewart, and Welch kraft mill at Port Alberni, B. C., and experiments were run with black liquor samples freshly collected from the pulp washer. The samples were taken in 60-ml. serum bottles which were filled to the top and immediately stoppered with rubber serum caps. The hypodermic syringe could be filled with liquor without removing the cap, and the liquor withdrawn was replaced by an equal volume of nitrogen. Under these conditions the black liquor could be stored for a considerable time without apparent alteration, and kinetic studies with fresh samples and samples stored for some weeks gave concordant results.

The black liquor was obtained principally from the pulping of Douglas-fir and western hemlock. The sodium sulphide content of the black liquor as found by the ammonium chloride evolution method of Bergstrom and Trobeck (*1*) was approximately 1.7 grams per liter. In order to simulate black liquor of higher sulphide content, gasesous hydrogen sulphide from a cylinder was injected into several vials of black liquor

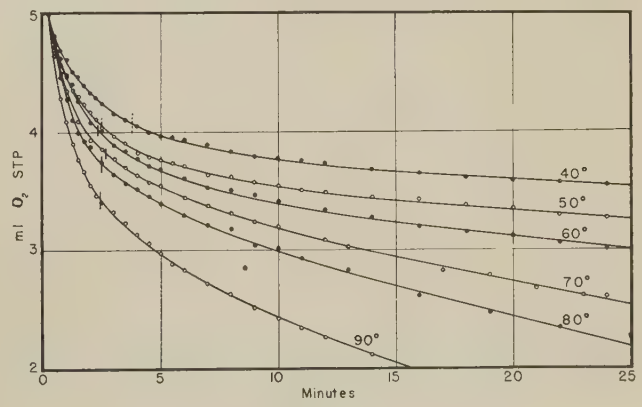

Fig. 2

using a 100-ml. hypodermic syringe. Analysis by the same procedure showed approximately 4.9 grams of sodium sulphide per liter. Black liquor containing added hydrogen sulphide is referred to below as "reinforced black liquor."

A typical series of measurements with weak black liquor is shown in Fig. 2, and with reinforced black liquor in Fig. 3. It can be seen that there was an initial rapid absorption of oxygen which gradually slowed down and continued apparently indefinitely.

The kinetic analysis of these curves is necessarily indirect. The general expression for a reaction rate, namely, $dx/dt = k\ (a-x)\ (b-x)$, etc., involves the term $(a-x)$ which is the concentration of a reactant remaining at time t. In these experiments the initial concentration of oxidizable material, a, was unknown, although the volume of oxygen taken up was a measure of x. Under such conditions it is usual to evaluate a by continuing the experiment to infinite time so that V_∞ is a measure of a and the equation can be written, for a first-order reaction,

$$\frac{dV}{dt} = k(V_\infty - V)$$

This again, was not possible in these experiments, because of the time required and the probable multiplicity of reactions taking place in the black liquor. The following procedure was therefore adopted:

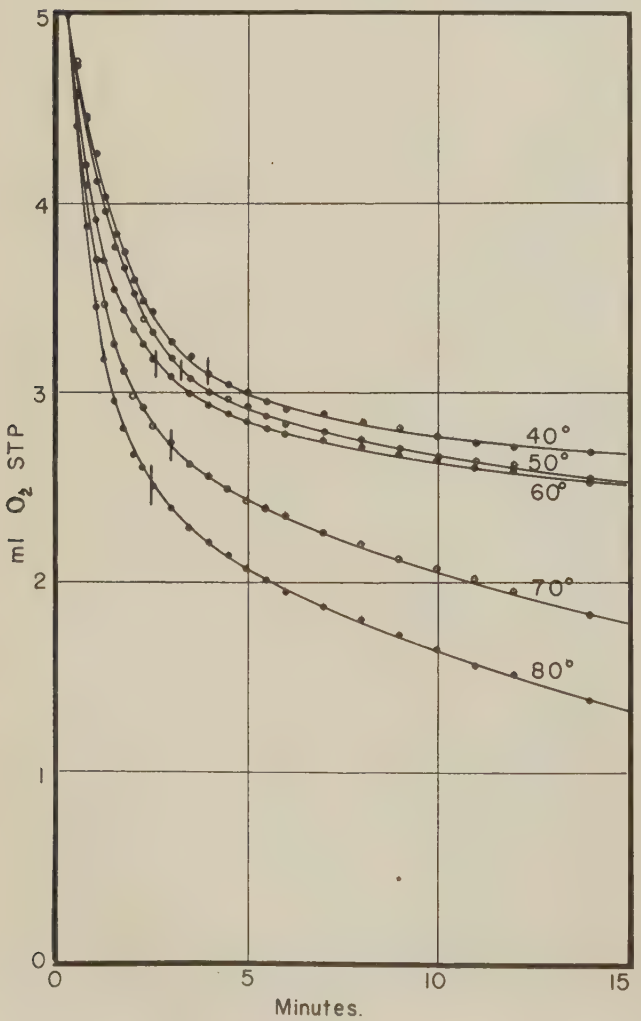

Fig. 3

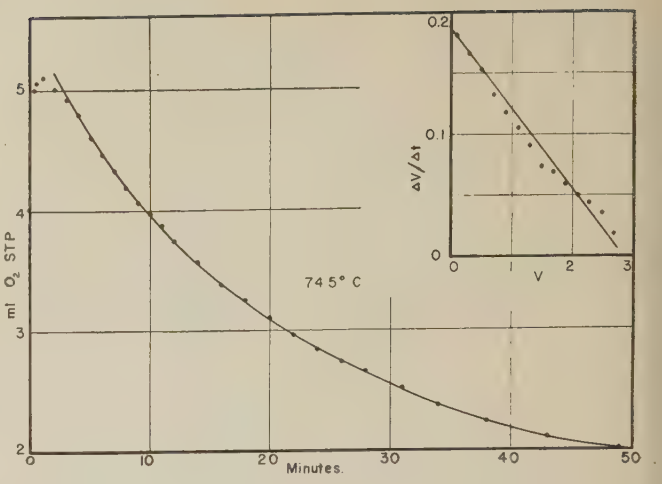

Fig. 4

Assuming a first-order reaction,

$$\frac{dV}{dt} = k(V_\infty - V)$$

$$= kV_\infty - kV$$

Differentiating,

$$\frac{d}{dV}\left(\frac{dV}{dt}\right) = -k$$

Thus, if the reaction is first order, plotting the slopes of the curves in Figs. 2 and 3 against the corresponding values of V, should give a straight line whose slope equals $-k$. However, instead of taking the actual slopes, obtained by drawing tangents to the curves in Figs. 2 and 3, it was more convenient to pick off the actual value of t at a series of regularly spaced values of V and to compute values of $\Delta V/\Delta t$. The results of this treatment for sodium sulphide oxidation are shown in Fig. 4. In this experiment, 1 ml. of a standard solution of sodium sulphide in $N/5$ sodium hydroxide was oxidized. The concentration of sodium sulphide, determined iodimetrically, was 11.4 grams per liter. As can be seen from the figure, there were some irregularities at the beginning of the reaction, presumably due to liberation of gas, but a very steady reaction rate curve was obtained thereafter. The inset to Fig. 4 shows the straight line relationship obtained by plotting values of $\Delta V/\Delta t$ against V.

Figures 5 and 6 show the corresponding plots for the reaction rate curves given in Figs. 2 and 3. It will be seen that in general very satisfactory straight line relationships were obtained with the exception of the experiments using the weak black liquor at 40 and 50°C. It will be seen also that the straight line relationship and the graphs in Figs. 5 and 6 all flatten out at the lower end.

The explanation of this flattening out is probably as follows:

If we have two first-order reactions such that,

$$\frac{dV_1}{dt} = k_1\ (V_{1\infty} - V_1)$$

and

$$\frac{dV_2}{dt} = k_2(V_{2\infty} - V_2)$$

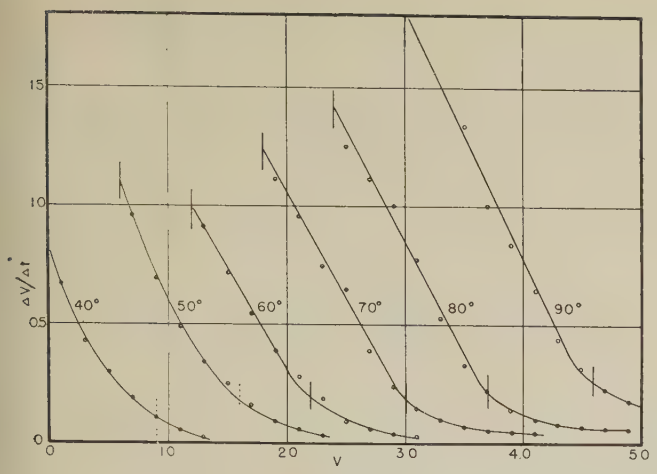

Fig. 5

then

$$\frac{dV}{dt} = \frac{dV_1}{dt} + \frac{dV_2}{dt} = k_1V_{1\infty} + k_2V_{2\infty} - k_1V_1 - k_2V_2$$

$$= \text{const.} - k_1V_1 - k_2V_2$$

Substituting

$$V = V_1 + V_2$$

$$\frac{dV}{dt} = C - (k_1 - k_2)V_1 - k_2V$$

so that

$$\frac{d}{dV}\left(\frac{dV}{dt}\right) = -(k_1 - k_2)\frac{dV_1}{dV} - k_2$$

If $k_1 \gg k_2$ (reaction 1 much faster than reaction 2), then, when t is small,

$$\frac{dV_1}{dV} \approx 1, \qquad (V_1 = V)$$

and

$$\frac{d}{dV}\left(\frac{dV}{dt}\right) \approx -k_1$$

On the other hand, when t is large,

$$\frac{dV_1}{dV} \approx 0 \text{ (reaction 1 has become very slow)}$$

and

$$\frac{d}{dV}\left(\frac{dV}{dt}\right) \approx -k_2$$

Hence, the plot of dV/dt against V should consist of two straight extremities joined by a curved portion. Should the reaction consist of three first-order reactions of sufficiently different k values, the plot of dV/dt against V should have three straight parts and so on.

It is apparent from Figs. 5 and 6 that the first part of the black liquor oxidation process conforms reasonably well to the first-order law and that the point at which the reaction departs from the first-order formula can be fairly precisely located. If we assume, and this assumption is considered more fully below, that the initial part of the reaction is largely given up to the oxidation of sodium sulphide, the point at which the first-order formula ceases to be operative may be taken as marking the substantial completion of the oxidation of the sodium sulphide. These points have been marked by short vertical strokes in Figs. 5 and 6 and the corresponding points on the curves in Figs. 2 and 3 have been similarly marked.

With the exception of the 40 and 50° runs, the time required for the initial first-order reaction to become effectively complete is quite consistently in the range 2 to 3 minutes and changing the concentration of sodium sulphide is of secondary importance, as it should be because the time required for a first-order reaction to reach 99% completion is independent of the initial concentration of the reactant.

The assumption that sodium sulphide is among the first substances to be oxidized is supported by a number of pieces of evidence. In Fig. 8, the oxidation of black liquor at 40°C. was compared with the oxidation of black liquor containing added methyl mercaptan and hydrogen sulphide, respectively. It will be seen that the effect of the additions was to accelerate the reaction during its early stages, and the later reaction showed little if any acceleration.

A more direct demonstration was provided by the following experiments: A number of serum vials were purged with nitrogen, capped, and 5 ml. of black liquor were injected. The vials were placed in a thermostat at 70°C. and allowed to come to that temperature. They were then removed one by one and varying amounts of gaseous oxygen were injected by means of a hypodermic syringe. The vials were shaken and returned to the thermostat for 15 minutes and then removed and cooled and the sodium sulphide content of the liquor determined colorimetrically (*3*). The results of two such experiments are shown in Fig. 8.

It is evident that one of the first effects of the added oxygen was to reduce the concentration of sodium sulphide.

Comparison of Fig. 2 and 3 with Fig. 4 shows that oxygen was absorbed much more rapidly by black liquor containing sodium sulphide than by dilute sodium hydroxide containing sodium sulphide. The black liquor must therefore contain substances which catalyze the oxidation of sodium sulphide. This is borne out by the results shown in Fig. 9.

The upper curve shows the result of an experiment in which mercaptan dissolved in $N/3$ sodium hydroxide was oxidized at 50°C. The lower curve shows the acceleration achieved when 2% (by volume) of black liquor was added to the mercaptan solution. The acceleration, especially during the earlier stages of the reaction, is evident. The initial rise in the curves is undoubtedly due to the volatility of the mercaptan.

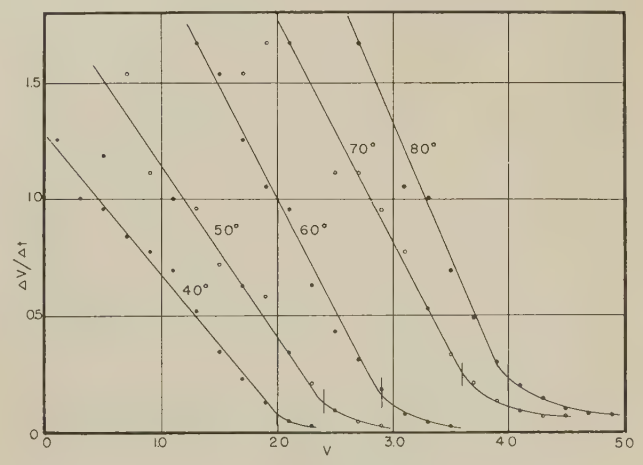

Fig. 6

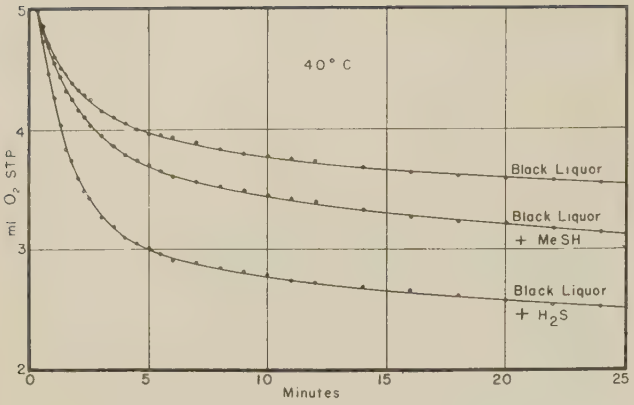

Fig. 7

The nature of the catalytic substances was not explored but it has been reported (*2*) that tannic acid or tannins, phenolic acids, like gallic acid, and polyhydroxy benzenes, such as pyrogallol and hydroquinone, are effective catalysts for the oxidation of mercaptans in aqueous alkaline solutions. Black liquor would be expected to contain substances of this type so that the observed results are readily accounted for.

As was shown above the rate constant of the first-order reaction is measured by the slopes of the straight $\Delta V/\Delta t$ lines in Figs. 5 and 6. The usual marked effect of temperature on the reaction rates is conspicuously absent, and the rate constants remain substantially the same in the range 60 to 90°C. This is probably accounted for by the fall in partial pressure of oxygen due to the greater partial pressure of water vapor at the higher temperatures. The reaction is, of course, only pseudo first order since the oxygen pressure, which would be expected to affect the rate, was effectively constant throughout each experiment because of the large excess of air used. The experiments were carried out under a constant total pressure of 1 atmosphere so as to conform to the conditions likely to be encountered in an oxidation unit.

The volume of oxygen required (measured at S.T.P.) tends to increase at higher temperatures (Figs. 2 and 3).

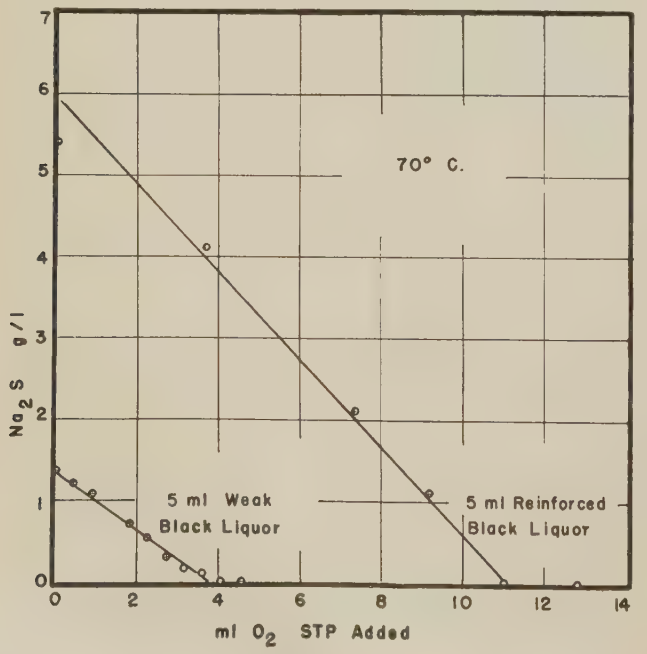

Fig. 8

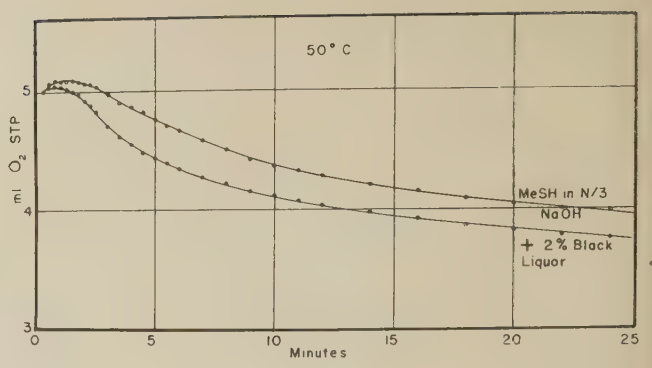

Fig. 9

Since the oxidation of sodium sulphide is certainly not the only process taking place, this is not altogether unexpected. In general it may be concluded on the basis of these results that 1 volume of black liquor requires from 1 to 3 volumes of oxygen or 5 to 15 volumes of air (measured at S.T.P.) to oxidize the sodium sulphide and similar compounds contained in it.

SUMMARY

The rate of oxygen absorption from moist air at 1 atmosphere total pressure by sulphate black liquor has been studied between 40 and 90°C.

The results are interpreted on the basis of simultaneous reactions which include a first-order reaction which is dominant during the first part of the process and is succeeded by slower reactions which continue indefinitely.

It is suggested that the oxidation of sodium sulphide takes place largely during this initial phase of the reaction.

The first phase requires a period of the order of 2 to 3 minutes for completion. This is the reaction time when the black liquor is given a large specific surface by absorption on filter paper. At smaller values of the specific surface the time would be materially longer. On the other hand, it would not be materially shortened if the surface were still further increased.

Between 60 and 90°C. temperature has very little effect on the specific reaction rate, probably because the partial pressure of oxygen falls as that of water vapor rises. The reaction time is therefore substantially constant in this temperature interval.

One volume of black liquor requires from 1 to 3 volumes of oxygen or 5 to 15 volumes of air for complete oxidation of the sodium sulphide. In practice larger volumes would have to be supplied lest the reaction be retarded by a fall in the partial pressure of oxygen.

Sodium sulphide and methyl mercaptan are oxidized more rapidly in black liquor than in aqueous alkali, probably because of the presence of catalysts derived from the wood.

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Comparative Investigations on Native and Isolated Lignin

ERIK HÄGGLUND and HERMANN RICHTZENHAIN

To characterize any possible differences between the isolated and the native lignin in wood the alcoholysis and the sulphonation of wood have been compared with that of a carefully prepared hydrochloric acid lignin. Also studied was the influence of methylation on the course of these reactions.

THE isolation of lignin from wood, even when carried out as carefully as possible, may involve chemical changes which cannot be recognized by analytical means. In order to characterize any possible differences between the isolated and the native lignin in the wood we have compared the alcoholysis and the sulphonation of wood with that of a carefully prepared hydrochloric acid lignin. We have also studied the influence of methylation on the course of these reactions.

When wood is heated with alcohols—ethanol was used in our experiments—in the presence of hydrogen chloride, the lignin takes up alkoxyl groups and three different lignin fractions are obtained. About 10% of the lignin is found in a water-soluble fraction which, according to H. Hibbert, consists mainly of monomeric guaiacylpropane compounds such as alpha-ethoxypropioguaiacone. Further, the so-called alcohol lignin (corresponding to nearly 30% of the total lignin) is formed. This is a phenolic compound which is soluble in alcohol, acetone, acetic acid, and dioxane. The rest of the lignin remains undissolved. Concerning the course of the alcoholysis a few points seem to be of particular interest. It is conceivable, for instance, that the solubilized phenolic compounds condense with undissolved lignin in a secondary reaction. It should then be possible to get higher yields of soluble compounds if the easily condensing phenolic groups in the wood or in the isolated lignin are methylated prior to the alcoholysis. Further it was considered necessary to examine whether the free-phenolic hydroxyl groups present in the guaiacylpropane derivatives detected and elucidated by Hibbert are present as such in the wood or whether they are liberated during the alcoholysis. In the former case these compounds could be regarded as end groups of the lignin molecule.

The following table gives the results of the alcoholysis of wood and hydrochloric acid lignin, respectively, untreated as well as methylated with diazomethane or with dimethylsulphate and alkali.

Table I shows that it is impossible to increase by a previous methylation the yield of either the water-soluble oils or the corresponding alcohol lignins. Furthermore, the result that the hydrochloric acid lignin preparations furnish practically the same yields as the corresponding wood preparations, seems to be of considerable interest. A hydrochloric-phosphoric acid lignin gave much lower yields of the soluble compounds. This indicates that the yields essentially depend on the conditions used in the isolation of the lignin.

Regarding the composition of the water-soluble oils obtained from the different experiments, no essential differences could be found. The main part is soluble in alkali and consists predominantly of alpha-ethoxypropioguaiacone. As it is probable that all phenolic groups of the wood and the hydrochloric acid lignin are blocked during the methylation, it may be concluded that the phenolic groups present in the isolated guaiacylpropane derivatives are not free in the lignin of the wood and in the hydrochloric acid lignin, but that they are liberated during the alcoholysis.

Table I

Starting material	*Yields of water-soluble oils*	*Alcohol lignin*
Spruce wood	10–12	20–34
Spruce wood treated with diazomethane (9.28% OCH_3)	11.9	26.5
Spruce wood treated with diazomethane (12.70% OCH_3)	13.1	33.5
Spruce wood treated with dimethylsulphate and alkali (30.4% OCH_3)	12	33
Hydrochloric acid lignin	11	29.3
Hydrochloric acid lignin treated with diazomethane (21.1% OCH_3)	9	36
Hydrochloric acid lignin treated with dimethylsulphate and alkali (29.5% OCH_3)	11.7	36
Hydrochloric-phosphoric acid lignin	4	20

The alcohol lignins from unmethylated wood and unmethylated hydrochloric acid lignin are easily soluble in dilute alkali. The alcohol lignins from the methylated starting materials, however, are only very slightly soluble in cold dilute alkali. Nevertheless, they contain phenolic groups, as is shown by the fact that they are precipitated from their solutions in alcoholic potassium hydroxide by carbon dioxide but not by water. The number of phenolic hydroxyls in the various alcohol lignin preparations has been determined by potentiometric titration of their pyridine solutions with sodium ethylate. (See Table II.)

Both unmethylated wood and hydrochloric acid lignin yield alcohol lignins with an equivalent weight of about 400, which means that 1 phenolic group is present for every 2 lignin units. Methylated wood yields preparations with an equivalent weight of about 600; consequently they contain 1 phenolic group for every 3 lignin units. The alcohol lignins from methylated hydrochloric acid lignin contain only 1 phenolic group for 4 to 5 lignin units. If the alcoholysis is carried out in two steps, the alcohol lignin from the first extract contains less phenolic but more alkoxyl groups than the alcohol lignin from the second extract. The alcohol lignins from methylated wood contain more phenolic groups than those from methylated

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hydrochloric acid lignin; whereas the former contains 1 phenolic group for about every 3 units, the latter contain only 1 phenolic hydroxyl for 4–5 units. It is possible that the excess phenolic groups found in the first-mentioned product are linked to carbohydrates in the wood itself. Apart from this difference our hydrochloric acid lignin shows the same behavior during alcoholysis as the lignin in the wood.

Table II

Starting material	*Equivalent weight of the alcohol lignins*	*Total alkoxyl calculated as OCH_3*
Spruce wood	406	21.08
Spruce wood treated with diazomethane (9.28% OCH_3)	563	23.14
Spruce wood treated with diazomethane (12.7% OCH_3)	610	23.03
Spruce wood treated with dimethylsulphate and alkali (30.4% OCH_3)	635	28.97
Hydrochloric acid lignin		
First extraction	421	22.63
Second extraction	402	21.95
Hydrochloric acid lignin treated with diazomethane (21.1% OCH_3)		
First extraction	804	26.64
Second extraction	652	25.09
Hydrochloric acid lignin treated with dimethylsulphate and alkali (29.5% OCH_3)		
First extraction	994	30.80
Second extraction	812	29.47

It is known that the sulphonation of the lignin proceeds in two steps. In the first step the so-called solid lignosulphonic acid is formed by a sulphonation in the solid phase, whereas the second step includes both dissolution and further sulphonation. The solid lignosulphonic acid contains generally 1 sulphur atom for 3.5–4 lignin units. Sulphonation at pH 5 to 6 affects only the first step and no dissolution of larger amounts of lignin takes place. The insoluble lignosulphonic acid present in low-sulphonated wood or in sulphite pulps rich in lignin can be solubilized by a procedure described by Kullgren. According to this procedure the metal ions of the material are replaced by hydrogen ions, and the free lignosulphonic acids extracted by heating with water or alcohols. In the latter case alkoxyl groups enter the lignosulphonic acid. On heating wood with sulphite solutions of low pH—e.g., under the conditions of the technical sulphite pulping process—the dissolution of the lignin is accompanied by further sulphonation, the final product containing 1 atom of sulphur for about 2 lignin units.

Since it is unknown whether or not the lignin in the wood is chemically linked to carbohydrates it is impossible to say if the fission of such a linkage plays any part in the dissolution of the lignin. Alternatively, it is possible that the dissolution of the lignosulphonic acid is effected simply by a fission of the lignin molecule into soluble fragments. It is even possible that both types of reaction take place simultaneously. Provided that our hydrochloric acid lignin does not differ essentially from the native lignin, an examination of this problem using the hydrochloric acid lignin instead of wood should be of interest.

When hydrochloric acid lignin is heated for 10 hours at 135° with an acid sulphite cooking liquor it is practically completely dissolved (Fig. 1). The lignosulphonic acid formed, the main part of which can be precipitated with organic bases such as bis-dimethylaminodiphenylmethane, contains on the average 1 atom of sulphur for 2 lignin units. It therefore corresponds to the lignosulphonic acids obtained from wood.

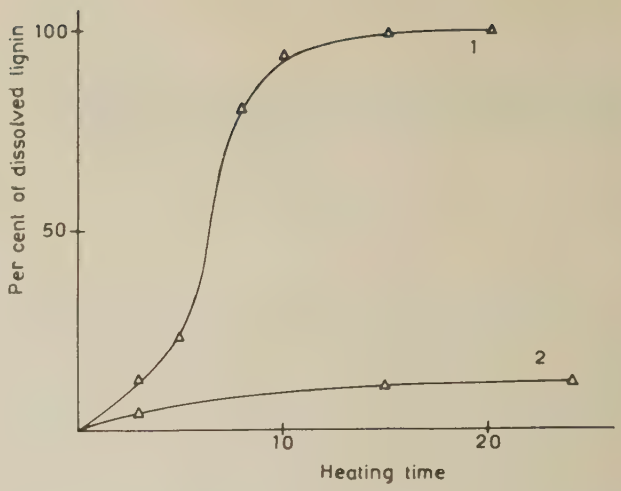


Fig. 1. Sulphite cooking of hydrochloric acid lignin

If hydrochloric acid lignin is sulphonated at pH 5 to 6, the main part of the lignin remains undissolved and contains about 1 sulphur atom for 4 lignin units. After replacing the metal ions by hydrogen ions this insoluble lignosulphonic acid can be dissolved by heating with water or alcohol. It thus shows the same behavior as the solid lignosulphonic acid in the wood. This dissolution of the low-sulphonated hydrochloric acid lignin is obviously due to a hydrolytic fission of linkages between lignin units. It is not yet possible to decide whether the dissolution of the lignosulphonic acid from the wood also depends on such a fission of lignin-lignin linkages or whether, in addition, it involves the fission of lignin-carbohydrate linkages. Differences have been shown to exist between the behavior of HCl lignin and that of wood; for instance, the dissolution velocity of the lignosulphonic acid from sulphite pulp or from low-sulphonated wood is considerably lower than that of the low-sulphonated hydrochloric acid lignin. Furthermore, the dissolution of low-sulphonated lignin from wood never goes to completion whereas the low-sulphonated hydrochloric acid lignin is quantitatively dissolved.

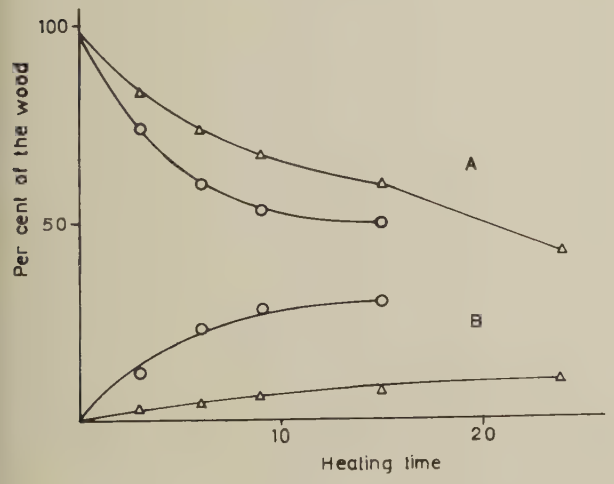
Concerning the influence of methylation on the sulphonation of lignin it is known that methylated wood is resistant to sulphite cooking. F. E. Brauns found that wood which has been methylated with diazomethane (17.6 OCH_3) takes up about 0.5% sulphur on sulphite cooking without any appreciable delignification taking place. Brauns suggested that the dissolution of the lignosulphonic acid is hindered by the blocking of a specific hydroxyl group in the lignin during the methylation with diazomethane, thus preventing the hydrolysis of a lignin-carbohydrate linkage. We have studied this problem with methylated wood as well as methylated hydrochloric acid lignin and tried to examine which step of the sulphonation is hindered by the methylation.

Spruce wood methylated with dimethyl sulphate and alkali to a methoxyl content of 37% does not take up any sulphur even on 41 hours' treatment with sulphite solutions of pH 5 at 135°. On heating for 24 hours with an acid cooking liquor about one third of the lignin is dissolved. The ultraviolet spectrum of the nearly colorless liquor shows a minimum at 263 mmu and a maximum at 278 mmu, which is quite normal for lignin derivatives. An investigation of this lignin fraction is in progress. It is very remarkable that under these conditions, part of the methylated cellulose seems also to be dissolved. That the inhibition of the sulphonation is actually due to the methylation and not to the alkali present during the methylation has been shown by the sulphonation of alkali-treated wood. In this case the lignin was dissolved in a normal manner (Fig. 2).

Methylated hydrochloric acid lignin proved to behave quite similar to the methylated wood. Sulphonation with neutral sulphite solutions was strongly inhibited by the methylation (Fig. 3). On 64 hours heating with a sulphite solution of pH 6, a preparation methylated with diazomethane took up only 1.34 % sulphur, that is, 1 sulpho group for about 10 lignin units. A preparation methylated with dimethyl sulphate and alkali took up still less sulphur. On heating with an acid bisulphite solution hydrochloric acid lignin, methylated with diazomethane or with dimethylsulphate and alkali, was dissolved to the extent of about 50 or 20% respectively.

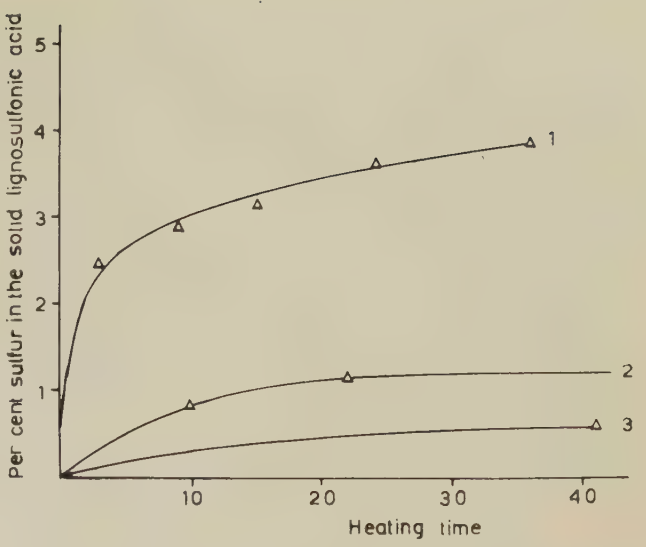
These experiments distinctly show that it is the first step of the sulphonation which is strongly inhibited by the methylation. The second step—the dissolution of the solid lignosulphonic acid—is much less affected by the methylation. This is also clear from the following experiments.

Spruce wood which had been sulphonated at pH 6 and which contained 1 sulphur atom for about 4 lignin units was methylated with diazomethane (12.2% OCH_3). From this material the solid lignosulphonic acid could be readily dissolved by heating with an acid sulphite solution, or with water, according to the Kullgren procedure. Similarly, it has been found by Adler that a lignosulphonic acid, which has been extracted from low-sulphonated wood and then methylated with diazomethane, can be further sulphonated by subsequent heating with acid sulphite solution. Dissolution experiments with low-sulphonated and subsequently methylated hydrochloric acid lignin yielded results quite similar to those obtained with low-sulphonated wood. On heating with water after cation exchange, a preparation methylated with diazomethane was dissolved to the extent of 81%, whereas a preparation methylated with dimethyl sulphate and alkali was practically completely dissolved.



Cooking liquor: 5% total SO_2. 1.4% NaOH. Temp. 135°C.
- ○ Spruce wood pretreated with alkali.
- △ Spruce wood pretreated with dimethylsulfate and alkali.
- A: Residue after sulfite cooking.
- B: Dissolved lignin (by spectrophotometric estimation).

Fig. 2. Sulphite cooking of wood after treatment with dimethylsulphate and alkali



Curve 1: Hydrochloric acid lignin.
" 2: " " " " methylated with diazomethane
" 3: " " " " methylated with dimethylsulfate and alkali

Fig. 3. Neutral sulphite cooking of hydrochloric acid lignins (pH 6)

In an attempt to eliminate any influence exerted by the carbonyl groups present in the lignin on the sulphonation, hydrochloric acid lignin was treated with methyl magnesium iodide. However, after such treatment hydrochloric acid lignin could be normally sulphonated at pH 6, and the resulting solid lignosulphonic acid could be normally dissolved. Similarly, no effect on the dissolution was observed, when hydrochloric acid lignin was pretreated with Grignard reagent.

To summarize, these results led to the conclusion that the sulphonation in the solid phase plays the decisive role in the delignification of the wood. Methylation of the lignin largely prevents this first step of sulphonation in neutral solution. In acid solution this first sulphonation proceeds at a low rate, resulting in the dissolution of part of the lignin.

The question now arises which groups in the lignin are responsible for the reaction with sulphite. It has been assumed that sulphonation in neutral solution involves the replacement of α-phenylcarbinol groups by sulpho groups. This reaction proceeds very quickly if the *p*-position to the phenylcarbinol group is substituted by a free phenolic hydroxyl as, for instance, in vanillyl alcohol. It proceeds more slowly if this phenolic group is etherified as, for instance, in veratryl alcohol. If it is assumed that the sulphonation in neutral solution is solely due to a sulphonation of such phenylcarbinol

groups, every fourth lignin unit should contain an α-phenylcarbinol group. However, according to Freudenberg and Dietrich cuproxam lignin contains only one α-phenylcarbinol group for 12 lignin units. It seems to be possible, on the other hand, that benzylalkyl ethers are split during the sulphonation. Recent experiments carried out by B. Lindgren have shown that pinoresinol is sulphonated at pH 6, whereas the methyl ether of pinoresinol is resistant to sulphonation at that pH value. Therefore, it seems possible that in lignin p-hydroxybenzyl ether groups are responsible for the first step of the sulphonation. This would also explain the fact that after methylation only a little sulphur is taken up by the lignin if the sulphonation is carried out in neutral solution.

Regarding the dissolution of the solid lignosulphonic acid, the experiments of H. Erdtman have demonstrated that during the dissolution a new group is formed which can be sulphonated. This group is probably a hydroxyl group in the benzyl position. If dissolution of the solid lignosulphonic acid is effected by means of alcohols instead of water an alkoxyl group is formed instead of a hydroxyl group. On further sulphonation the alkoxyl group can be replaced by a sulpho group. On the basis of our experiments with low-sulphonated hydrochloric acid lignin it appears probable that the dissolution of low-sulphonated lignin involves the fission of linkages between lignin units. As yet, it cannot be decided whether these hydrolyzable lignin-lignin linkages are of the acetal type or of the benzyl ether type.

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Electrochemical Recovery of Sodium Base and of Oxalic Acid from Sulphite Waste Liquor

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Although the neutral sulphite process for pulping woods has many merits, a practical method of recovering the expensive sodium base is not one of them. The present article describes laboratory-scale experiments in which over 90% of the sodium was recovered, as nearly pure caustic soda of up to 2% concentration, by electrolyzing the waste liquor in a cell with a porous clay diaphragm and a nickel cathode. Electrical efficiencies ranged up to 70% in a four-stage electrolysis, and the average value of 55% corresponded to the consumption of about 2.2 kw.-hr. per pound of caustic soda recovered. The oxidation of purified, carbohydrate-free sodium lignosulphonate was studied under strongly alkaline conditions in a cell with a copper anode and no diaphragm. Part of the sulphonic acid group was released as sulphuric acid, but oxalic acid dihydrate in up to 16% by weight was the only other acid identified. The production of the dihydrate required about 13.4 kw.-hr. per pound. The economic implications of the above results were briefly discussed.

Although Cross (*1*) patented the use of neutral sodium sulphite solutions for the pulping of jute fiber and wood as early as 1880, it was 1926 and later before detailed studies of the process were published by workers at the U. S. Forest Products Laboratory (*2, 3, 4*) and elsewhere (*5*). The addition of sodium bicarbonate to the pulping liquor neutralized the acids formed during the digestion and thereby greatly reduced the damage to the carbohydrate portion of the wood without hindering delignification (*4, 6*). More recent work (*7–10*) established the versatility of the process with various woods and the merits of the resulting high-yield pulps in respect to ease of hydration, strength, and other desirable qualities. On the other hand, the expensive sodium base could not be conveniently recovered by burning the neutral sulphite waste liquor because of the production of sulphide as well as of carbonate (*5*); neither could the sodium be replaced by the cheaper calcium or magnesium neutral sulphites because they were too sparingly soluble in water. Pulping on the large scale by this method has therefore been restricted, although not by any means suppressed (*10*).

The present article describes attempts to recover aqueous sodium hydroxide from neutral sulphite waste liquor by electrochemical methods similar to those used by Dyfverman (*11*) in analogous experiments with black liquor from the kraft process. Although Dyfverman obtained yields of up to 80% in a practically pure state from the cathode chamber of an electrolytic cell, the accumulation of organic deposits on the anode caused considerable difficulty. A similar attempt by Shinn (*12*) to recover calcium hydroxide from the waste sulphite liquor was unsatisfactory because the precipitation of the carbonate about the cathode impeded the operation of the cell. Bender (*13*) attempted to overcome these difficulties by using a revolving steel cathode with a doctor blade to remove the deposit, which contained, in his case, about 22% of calcium and magnesium as the oxides and liberated about 7.3% of sulphur dioxide when treated with acid. In spite of these precedents, the efficient large-scale production of caustic soda from aqueous sodium chloride in cells of the diaphragm or mercury electrode types (*14*) suggested that the recovery of caustic soda from sodium lignosulphonates deserved more investigation.

Any cell that produced sodium hydroxide (and hydrogen) at the cathode would simultaneously tend to oxidize the acids liberated at the anode. According to Shinn (*12*), some demethylation of the lignosulphonic acids occurred, together with the liberation of a little sulphuric acid and considerable amounts of carbon

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dioxide. The drastic electrochemical oxidation of a butanol lignin in 1% caustic soda was reported to result in an 82% yield of low molecular ketones and acids, including 3.1% of oxalic acid (*15*). The present experiments also employed an alkaline instead of an acid medium and cells different from those used for the recovery of sodium hydroxide. In studying the anodic oxidation of the lignosulphonates, interference arising from the oxidation of carbohydrates was avoided by first dialyzing the crude sodium lignosulphonate until free of carbohydrates.

EXPERIMENTAL

Crude Neutral Sulphite Waste Liquors

A 400-gram batch of commercial sized chips from black spruce (*Picea mariana;* moisture 25%) was charged into a 2-liter stainless steel bomb containing 950 ml. of a liquor prepared by dissolving 112 grams of neutral sodium sulphite, and 20 grams of sodium carbonate in 1 liter of water. After the chips had soaked for an hour, the bomb was sealed and uniformly heated to 120°C. during 1 hour and kept at this temperature for a further hour. The pressure was then relieved from the bomb in order to release carbon dioxide; thereafter the temperature was raised to 175°C. during 2 hours and kept at this point for $2^1/_2$ hours. The bomb was then quenched in cold water and opened, the digested chips were washed with the minimum amount of water, and after filtration the combined liquors were concentrated at atmospheric pressure. Bumping and caking during the concentration were prevented by using a stirrer equipped with drag links. The concentrates from six similar cooks were combined and stored in sterilized glass bottles.

Total solids in the liquor were determined by the evaporation of 5-ml. aliquots to constant weight at 55°C. *in vacuo* (*16*), ash by incineration, finally with a drop of concentrated sulphuric acid (*16*). When the weight of this "sulphated ash" was multiplied by the calculated factor 0.324 the result was equivalent to the weight of sodium present; the total amount of sodium ion present was also determined by precipitation as the insoluble sodium-zinc-uranyl acetate complex, $Na\text{-}(C_2H_3O_2) \cdot Zn(C_2H_3O_2)_2 \cdot 3UO_2(C_2H_3O_2)_2 \cdot 6H_2O$, according to the TAPPI procedure T 623 m-44 (*16*). Found: total solids, 5.8, 5.8%; sulphate ash, 3.72, 3.67%, corresponding to 1.21, 1.19% of sodium. The uranyl acetate method gave Na 1.19, 1.20%.

The residual pulp had a Klason lignin content of 10.4% (T 222 m-43) and developed a maximum burst factor of about 95 when beaten for about 95 minutes according to the TAPPI procedure T 200 m-45.

Purified Lignosulphonic Acids

Some of the above chips were broken up in a Mead mill and thoroughly extracted for 48-hour periods with constant-boiling alcohol-benzene (1:2 vol.) to remove waxes and resins that might have contaminated the product. The cook was as already described save that the final temperature of 175°C. was reached in $2^1/_2$ hours after sealing the bomb and was maintained for 4 hours. Concentration of the waste liquor was under diminished pressure.

Although electrodialysis removed sodium, sulphate, and sulphite ions efficiently from the liquor, it was less effective with carbohydrates, and breakage of the cellophane diaphragms frequently caused loss of material. It was more satisfactory to employ ordinary dialysis through cellophane sausage casing against a continuous stream of water (*18*). Although the casing was originally filled only one-third full with the concentrated liquor, the salts present caused the imbibition of so much water during 2 days that the liquor had to be removed and reconcentrated under vacuum. After an additional 6 or 7 days of dialysis, aliquots of the liquor had lost their original copper-reducing power both before and after hydrolysis with 1 *N* hydrochloric acid (*16*), so that sugars and polysaccharides were no longer present. A standard estimation for pentosans (T 223 m-43) also gave a negative result. Found: total solids, 7.07, 7.06%; sulphated ash, 0.739, 0.736%; whence sodium, 0.239, 0.238%.

Sodium ion was removed from the liquors by passage through a column containing Amberlite 1R-100-H analytical grade cation exchange resin obtained from Rohm and Haas Co., Philadelphia, Pa. (*18*). In analytical work the procedure of Yorston (*16*) was followed except that a column of 7 mm., instead of 12 to 14 mm., internal diameter was constructed. This size was convenient for 10-ml. or even 5-ml. aliquots, which were recovered in a standard volume of 25 ml. instead of 100 ml. at the foot of the column. Found for the above liquor, after correction for dilution: total solids, 6.38, 6.24%; ash, 0.01, 0.01%; S, 4.9, 5.1%; OCH_3, 8.71, 8.63%. The sulphur and methoxyl analyses, for which the authors thank their colleague, L. G. Neubauer, were obtained on the solid lignosulphonic acid, and corresponded to an OCH_3: S ratio of 1.8:1.

A 5-ml. sample of the diluted, ash-free liquor was then titrated conductometrically with 0.1 *N* potassium acetate in 95% acetic acid, Yorston's procedure (*16*) being followed. This procedure responded only to "strong acids," like lignosulphonic and free sulphuric acids, but was indifferent to the weaker organic acids. When sulphuric acid was present, it was convenient to add an excess (1 ml.) of 0.5 *N* barium acetate to a fresh 10-ml. aliquot of the liquor, and to remove the precipitated barium sulphate 10 minutes later on the centrifuge. The liquor was then de-ashed by passage through the ion-exchange column and a conductometric titration of the effluent gave estimated "strong acids" with the exception of sulphuric, which was determined by difference. Control experiments showed that this modification gave values for lignosulphonic acid that closely checked those obtained in the somewhat longer gravimetric method described by Yorston. The total acidity, which included that originating with organic acids, was determined by a potentiometric titration to about pH 7.5 with standard alkali, the organic acids being the difference between this result and that for "strong" acids. If x, y, and z represented the normalities of the sulphonic, sulphuric, and organic acids, respectively, then the first conductometric titration revealed $x + y$, the second x alone, and the final potentiometric titration gave $x + y + z$. Oxalic acid was estimated on a separate aliquot by precipitation as the calcium salt, which was titrated with acid 0.1 *N* potassium permanganate.

Recovery of Caustic Soda

The cell for the recovery of caustic soda consisted of a cylindrical glass vessel, 11 cm. in diameter and 12 cm. deep, containing a sheet lead anode 10 cm. in diameter and 11 cm. high. Inside the anode was a porous clay vessel, 7.5 cm. in diameter and 12 cm. high, which served as a separating diaphragm. The cathode, a cylinder 6.0 cm. in diameter and 10 cm. high, arranged concentrically with the other elements of the cell, was constructed of sheet nickel fitted about a glass vessel, which served both as a support and as a filler to reduce the volume. Direct current from the 110-volt line was reduced and kept regulated by a series of resistances to the voltage desired, which was usually less than 6.

In a typical experiment, 100 ml. of the crude waste sulphite liquor was diluted with water to 200 ml. and charged into the outer anode compartment of the cell, while the cathode section was filled with 150 ml. of water. A voltmeter was connected across the electrodes, and the current through the circuit was measured by an ammeter, which was read at definite and frequent times, in order to estimate the coulombs (amperes × seconds) passed (Table I). At the end of the experiment, when the current produced by a nearly constant voltage was decreasing, the sodium transferred as caustic soda to the cathode compartment was determined by direct titration with 0.1 *N* hydrochloric acid and also by precipitation with the uranyl acetate reagent. The "recovery" was the percentage of the original sodium (in this case 1.2 grams) appearing as caustic soda in the cathode compartment. Since the transfer of 1 gram atom of sodium theoretically required 96,500 coulombs or 1 Faraday, of electricity, x coulombs corresponded to $23x/96{,}500$ grams of sodium. The "electrical efficiency" was the percentage which the observed recovery of sodium bore to the calculated amount.

Table I. Electrolysis of Crude Neutral Sulphite Liquor
(200 Ml. with 0.6% Na; Total Volume 250 Ml.)

Min.	*Amp.*	*Mean amp.*	*Coulombs*	*Volts*
0	0.07	...	..	3.5
5	0.08	0.075	23	3.3
40	0.14	0.11	154	2.7
70	0.17	0.155	279	2.2
105	0.17	0.17	357	2.2
170	0.14	0.155	605	2.0
230	0.12	0.13	468	2.1
290	0.12	0.12	432	2.0
350	0.10	0.11	396	2.0
410	0.10	0.10	360	2.0
470	0.10	0.10	360	1.9
530	0.09	0.095	324	2.0
590	0.09	0.09	324	2.0
650	0.08	0.085	306	1.9
710	0.08	0.08	288	2.0
770	0.07	0.075	240	2.0
830	0.07	0.07	252	2.0
890	0.05	0.06	212	2.0
		Total	5380	

NaOH recovered in cathode compartment, 0.71 gram Na.

$$\text{Recovery} = \frac{0.71 \times 100}{2 \times 0.6} = 59\%.$$

$$\text{Sodium equivalent of coulombs passed } \frac{5380 \times 23}{96{,}500} = 1.28 \text{ grams.}$$

$$\text{Current efficiency} = \frac{0.71 \times 100}{1.28} = 55\%.$$

Oxidation of Lignosulphonates

The cell for these oxidations consisted of a cylindrical glass jar of 1 liter capacity containing a copper anode, 12 by 12 cm., round its inner surface. The cathode, placed concentrically round a glass vessel weighted to hold it in place, consisted of platinum foil measuring 10 by 20 cm. A larger cell was also constructed in the same way with a 4-liter Pyrex beaker as the outer container, but with a sheet nickel cathode. No diaphragms were used.

When the smaller cell was used, liquor containing 10 grams of dialyzed and de-ashed lignosulphonic acids was added to water containing 40 grams of sodium hydroxide and the total volume was made up to 400 ml. The oxidation, with current of approximately 1.25 amp. at 2.5 volts was followed with conditions indicated in Table I so that the number of coulombs used was known at all times. When the oxidation had proceeded sufficiently far, as judged by the very marked lightening in the color of the solution, the latter was decanted, centrifuged, and extracted continuously with ether to remove any neutral products. These dark, viscous substances accounted for less than 1% of the lignosulphonic acids and were not examined in detail.

The aqueous residue was then strongly acidified with hydrochloric acid and again extracted continuously with ether, benzene, and chloroform in succession before being evaporated to dryness under reduced pressure to a dark resin that was not investigated. While the benzene extract contained no solids and that with chloroform only a very small amount of a brown oil, the ether extract on evaporation yielded up to 20% by weight of the lignosulphonic acid as light brown, crystalline needles. After recrystallization from ether petroleum–ether cooled to − 5°C., the white crystals melted at 99 to 100°C., and had a neutralization equivalent (*19*) of 62.2. Calculated for oxalic acid dihydrate, $C_2H_2O_4 \cdot 2H_3O$; neut. equiv. 63. The insoluble calcium salt was also prepared and when oxidized with 0.1 *N* acid potassium permanganate consumed 154.2 ml. per gram sample. Calculated for C_2O_4Ca, 156.3 ml.

When dried at 105°C., the melted crystals resolidified to a fine white powder melting at 183°C. Mixed melting points with authentic oxalic acid (183°C.), and of the original crystals with the dihydrate (100°C.), were undepressed.

RESULTS AND DISCUSSION

After attempting to recover sodium hydroxide from sodium base sulphite waste liquors in cells of various designs, the most satisfactory results were with one containing a clay diaphragm between a nickel cathode and a lead anode, operating with a difference of potential of 1 to 4 volts across the electrodes. The original crude sulphite liquors were first evaporated or diluted to different extents in the experiments summarized in Table II but in the three cases cited the initial volume placed in the anode compartment of the cell was 200 ml. The details of run 1 were given in Table I, together with the method of calculating the recovery and electrical efficiency. Run 3 shows that liquor from a soda-

ased acid sulphite cook responded as well as neutral ulphite liquor to the electrolysis. The maximum ecoveries of about 60%, however, made it unlikely hat a one-stage process would be practical.

Table II. Preliminary Recoveries of Sodium Hydroxide

	Crude neutral sulphite		*Crude acid sulphite,*[a]
	Run 1	*Run 2*	*Run 3*
Electrolysis			
Hours	15	65.5	5
Coulombs	5400	21,600	1800
Sodium			
In liquor, grams	1.2	8.1	0.291[b]
Recovered (as NaOH), grams	0.71	2.82	0.182[b]
Recovery, %	59	35	62
Current efficiency	55	54	42

[a] Laboratory cook with same lot of black spruce chips. Similar to commercial practice.
[b] By uranyl acetate method.

In the main experiment, 650 ml. of crude neutral sulphite liquor, containing 37.7 grams of total solids including 7.8 grams of sodium ion, was concentrated to 250 ml. before being electrolyzed for 6 hours (Table III)

Table III. Five-Step Electrolysis of Neutral Sulphite Liquor[a]

	Stage				
	1	*2*	*3*	*4*	*5*
Electrolysis					
Hours	6	16.7	7	16	24
Amperes	1.1	0.3	0.4–0.15	0.2–0.04	0.2–0.02
Volts	3.4	3–4	3.8–5.7	5.8	5.8
Coulombs	23,700	17,700	7000	6300	...
Sodium ion					
Original grams	7.8	5.2	2.29	1.38	0.65[d]
Recovered grams[b]	2.62	2.89	0.91	0.73	0.124
Recovered grams[c]	2.49	2.72	0.88	0.69	0.10
Recovered, %	33.6	56	39	53	18[d]
Cumulative recovery, %	34	75	82	92	93
Current efficiency, %	46	70	53	49	...

[a] Volume, 250 ml.; total solids, 37.7 grams; sodium ion, 7.7 grams
[b] By uranyl acetate method.
[c] By titration.
[d] Inaccurate owing to accumulated errors.

(stage 1). The caustic soda in the cathode compartment was then removed, analyzed, and replaced with water, whereupon the electrolysis was continued (stage 2). The sodium remaining at the commencement of subsequent electrolyses was obtained by difference. Almost complete removal of sodium ion was indicated by the decrease in current, even with a slightly increasing voltage, at the end of the fourth stage, when the total recovery as caustic soda was about 92%. A fifth stage recovered only an additional 1% of the base at most. The table also shows that the uranyl acetate analysis for sodium ion was slightly but consistently higher than the result based on the titration for alkalinity, the totals corresponding to 7.27 grams and 6.88 grams, respectively. The difference of 0.39 gram probably represented sodium ion present as undetermined salts instead of as caustic soda. On this basis, the final recovery was 93% as caustic soda of about 95% purity. In marked contrast to the very dark color of the liquor around the anode the caustic soda had only a light yellow shade. The clay diaphragm had therefore held back almost all of the lignosulphonic acids and colored contaminants. Since the concentration of recovered sodium ion averaged about 1.25% (final volume about 200 ml.), that of the caustic soda was about 2%, or sufficient without excessive concentration for re-use in the pulping cycle. When the current efficiencies were weighed with the number of coulombs used in the individual stages, the average was 55%. The lower efficiency in the first stage might have been caused by hold-up of sodium ion in the diaphragm, and those in the final stages because side reactions such as the discharge of hydrogen and the diffusion of sodium ions became of greater importance.

Let it be assumed that the liquor required to produce 1 ton of neutral sulphite pulp was obtained by adding sulphur dioxide to 480 pounds of technical sodium carbonate and costing at present delivered prices about $9.60. On this basis the recovery of 90% as aqueous caustic soda would effect a saving in raw materials of about $8.60, but the electric power consumed at 55% efficiency and 4 volts would be 2.2 kw.-hr. per pound of caustic soda, or about 460 kw.-hr. per ton of pulp. This power might cost about $2.30 and reduce the saving to about $6.30. The recovery of 190 pounds of caustic soda would also involve the production of $4^3/_4$ pounds of hydrogen gas with a fuel value of about 290,000 B.t.u. Osmosis during the electrodialysis tended to concentrate the lignosulphonic acids around the anode and they were heated very appreciably by the current. Beath and Hill (*20*), indeed, employed electric power to evaporate calcium-base sulphite waste liquor to a 50% solids content, and simultaneously to produce steam at pressures up to 150 p.s.i. These observations suggested that the further evaporation of the ash-free lignosulphonic acids might eventually prove feasible. In this event, the recovery of perhaps $^1/_2$ ton of concentrated waste liquor solids per ton of pulp would provide an additional net fuel value of the order of 3 million B.t.u., or about $1.50, and open up the possibility of recovering and recycling sulphur dioxide. Although the above estimates failed to include capital and other costs, they were made on a conservative basis. The electrical efficiency, for example, was assumed as 55%, whereas this figure might become 70%, or even 80%, in a three or four-stage set of carefully designed cells operating on the countercurrent system.

The oxidation of the carbohydrate-free sodium lignosulphonates in strong aqueous alkali was finally carried out in cells having a nickel or platinum cathode, a copper anode, no diaphragm, and operating at 3 volts or less. Oxalic and sulphuric acids were the only products of the oxidation that were definitely identified in three preliminary experiments, but the yields of crude oxalic acid were 20.4, 8.7, and 8.1% by weight. The consumption of coulombs per gram of oxalic acid isolated were about 43,000, 100,000, and 24,000, respectively. Such variable results led to a larger scale experiment, in which 50-ml. aliquots of the solution were withdrawn at various stages of the electrochemical oxidation and carefully de-ashed on an ion exchange column before examination. The purified lignosulphonic acid, with 0.01% ash, was first concentrated until 7.9 grams of solids occupied a volume of 300 cc., or 26.3 grams per liter. Since the sulphur content of the solids

was 5.0%, calculation showed 26.3 × 0.05/32 or 0.041 atom of sulphur was present per liter. Since the addition of excess barium acetate produced no precipitate, sulphuric acid was absent and the normality of 0.039 found for "strong" acids pertained to lignosulphonic acid alone. The concordance between the results supported published opinions that within the experimental error all the sulphur in purified lignosulphonic acids was present as a sulphonic acid grouping. A similar normality of 0.038 found by direct titration with alkali confirmed the conclusion (*21*) that no organic acids were present, and the absence of oxalic acid in particular was independently checked. As the oxidation proceeded (Table III) the current at nearly constant voltage eventually decreased markedly, and the dark color of the original lignosulphonic acid solution became much less intense. As expected (*12*) sulphonic acid groups were partially replaced by free sulphuric acid (estimated by difference) and the sum of these "strong" acids retained its original value of 0.039 equivalent per liter. The increase in the total acidity in the first two stages was accounted for entirely by the increase in oxalic acid, but at the end of stage three a residual acidity of 0.013 *N* indicated that other organic acids were probably accumulating. The failure of oxalic acid to increase in amount in stage three suggested that it was not entirely stable in the oxidizing conditions used, and that the value of 16.9% as the dihydrate was near the maximum. This yield was much

Table IV. Progressive Oxidation of Lignosulphonic Acids[a]

	Stage 1	Stage 2	Stage 3
Electrolysis			
Hours	6	6	21.8
Amperes	0.75–1.7	1.8–1.7	0.8–0.7
Volts	2.1–2.4	2.4–2.6	2.4
Coulombs[b]	19,200	57,200	115,100
Acid normality			
Total	0.076	0.0103	0.121
Sulphonic	0.0313	0.0275	
Sulphuric	0.0077	0.0115	0.39
Oxalic	0.04	0.07	0.069
Other	0	0	0.013
Oxalic acid dihydrate			
Grams	0.783	1.335	1.311
Per cent[c]	9.3	16.9	16.5
Coulombs per gram			
Oxalic acid	24,500	42,800	87,800
Sample	2,400	7,200	14,600

[a] Ash-free lignosulphonic acid, 7.9 grams with 5.0% sulphur, and 20 grams of sodium hydroxide in 300 ml. Acidity, 0.039 *N*. No sulphuric or organic acids present.
[b] Cumulative.
[c] Of original lignosulphonic acid.

more than the 3.1% previously obtained electrochemically (*15*) from butanol lignin, but fell considerably short of the maximum of 28 to 30% obtained by several workers (*22*, *23*, *24*) who digested various types of sulphite waste liquor solids with concentrated nitric acid.

The approximate consumption of coulombs required to produce 1 gram of oxalic acid (Table III) rapidly increased as the oxidation proceeded and amounted to 42,800 at the end of stage two. This figure, combined with the voltage of about 2.5, corresponded to 13.4 kw.-hr. or about 6.7 cents per pound of oxalic acid dihydrate. Such a high cost for power would appear to eliminate this oxidation as an economic source of oxalic acid, unless the operation could be made to form part of a greater one involving the electrical evaporation of neutral sulphite waste liquor or the recovery of the base therefrom.

In conclusion, the experimental evidence indicated that economic processes might be evolved for the electrochemical treatment of waste liquors of the sodium base sulphite and neutral sulphite pulping systems.

Alternative systems would include:

1. The electrolytic recovery and reuse of the sodium base accompanied with the evaporation and burning of the organic matter. Part of the sulphur dioxide formed by the combustion of the organic sulphur compounds would be recovered for combination with the sodium hydroxide to form fresh cooking liquor.

2. The liquor would first be treated with microorganisms to convert the carbohydrate portion into alcohol or yeast. Sodium base would be recovered and organic matter treated as in (1).

3. The liquor would be treated as in (2) but the organic matter would be converted into salable products, e.g., oxalic acid, tanning agents, dispersants, binders, etc. Research would undoubtedly find many other uses.

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ASSOCIATION NEWS AND EVENTS

Maine-New Hampshire Summer Meeting

The TAPPI Maine-New Hampshire Section will meet at the Belgrade Hotel, Belgrade Lakes, Me., on June 20 21, 1952.

A business meeting for the election of officers will be held on Friday morning, June 20.

The technical program for Friday afternoon will be devoted to stock clearing. The following papers will be presented:

1. "Problems of Clean Stock," by A. Jenkins, Bird Machine Co., South Walpole, Mass.
2. "The Oliver-Ahlfors Screen," by W. H. Pitkin, Oliver-United Filters, Inc., Oakland, Calif.
3. "Clean Stock with the Centre Cleaner," by Edwin V. Kemp, Bauer Bros. Co., Springfield, Ohio.
4. "Centrifugal Cleaning Equipment," by W. A. White, Shartle Bros. Machine Co., Middletown, Ohio.

A ladies bridge and canasta tournament will be held in the afternoon, and in the evening there will be a banquet and dance.

The Saturday morning program will feature the following presentations:

1. "How Our Business System Operates," by James P. Nolan, Training Director, Oxford Paper Co., Rumford, Me.
2. "The Forest and the Woodsman" (film).
3. "The Downingtown-Masson, Scott Supercutter" (film shown by L. E. Smith, Downingtown Mfg. Co., Downingtown, Pa.).

The Saturday luncheon will be held on the shore of Belgrade Lake and will be followed by a sports program, golf tournament, and fishing derby. In the evening prizes for these events will be given at the dinner.

All reservations for rooms should be made direct with the Belgrade Hotel, Belgrade Lakes, Me.

George A. Day, Brown Co., Berlin, N. H., is Chairman of the Maine-New Hampshire Section and Chairman of the Technical Committee. Associated with him are Arthur E. Jones, Oxford Paper Co., Rumford, Me., and Joseph J. Thomas, S. D. Warren Co., Cumberland Mills, Me.

The Local Arrangements Committee consists of W. L. Hinds, Keyes Fibre Co., Waterville, Me., Chairman. J. Fife Wright, National Aniline Division, Boston, Mass., and H. E. Pratt, Pejepscot Paper Co., Brunswick, Me.

S. D. Stroud, F. C. Huyck & Sons, Portland, Me., is Chairman of the Sports Committee. Associated with him are Mrs. W. L. Hinds, Waterville, Me., and F. A. Strovink, American Cyanamid Co., Boston, Mass.

Alkaline Pulping Conference

The TAPPI Alkaline Pulping Conference will be held at the Battle House, Mobile, Ala., on Nov. 12–14, 1952.

An organizational meeting was held on April 29 at the Battle House at which R. G. Macdonald, Secretary of TAPPI, and R. R. Fuller, Gulf States Paper Co., Tuscaloosa, Ala., Chairman of the TAPPI Alkaline Pulping Committee, presided.

Mr. Fuller announced that the theme of the meeting will be Sulphur Recovery, Soda Recovery, General Recovery Operations, and Reduction of Kraft Mill Odors.

Two days will be devoted to papers dealing with these subjects and the third day will be spent visiting the mills of the Southern Kraft Division of the International Paper Co. and the Hollingsworth & Whitney Co. in Mobile.

Anthony B. Pesch of the International Paper Co. and Robert B. Reynolds of the Hollingsworth & Whitney Co. will be Co-Chairmen of the Local Committee. Ion Walker of the International Paper Co. will be Secretary and Chairman of the Publicity Committee. George L. Witham of the Orr Felt & Blanket Co. will be Chairman of the Registration Committee; A. R. Skelton of the American Cyanamid Co., Chairman of Transportation Committee; and Joe B. Homan of A. E. Staley Mfg. Co., Chairman of the Arrangements and Hospitality Committee.

In addition to the individuals mentioned, the following were present at this meeting: John Beck of Hollingsworth & Whitney Co., J. W. Gilbert and G. S. Mabrey of the International Paper Co., and S. L. Bittner of S. L. Bittner & Sons, Inc.

Corrugated Combiner Conference

The TAPPI Corrugated Containers Committee will sponsor a Corrugated Combiner Conference at the Schroeder Hotel, Milwaukee, Wis., on Nov. 20–21, 1952.

On November 20, there will be visits to corrugating plants in Milwaukee.

The November 21 technical meeting will be devoted to presentations and panel discussions based on the Committee's Combiner Questionnaire.

Room reservation applications should be sent to Mr. Limecooley, Manager of the Schroeder Hotel. In mailing applications please mention your intention to attend the TAPPI Corrugated Containers Conference.

TAPPI Pulp Testing Committee

R. I. Thieme of the Soundview Pulp Division, Scott Paper Co., Everett, Wash., has succeeded Loren V. Forman, Scott Paper Co., Chester, Pa., as Chairman of the TAPPI Pulp Testing Committee.

Third Coating Conference

The Third Coating Conference of the Technical Association of the Pulp and Paper Industry was held at the Hotel Sherman, Chicago, Ill., May 5–8, 1952. It was very well attended by representatives of the coating industry and its suppliers from all over the United States as well as from Canada and Sweden. The total registration was 333 of which 250 attended the conference luncheon.

The Coating Committee was invited to hold its meeting in Chicago by the Chicago Section of TAPPI, and F. D. Long of the Container Corp. of America and V. V. Vallandigham of the Kelco Co., as representatives of the Section, spent many hours completing the arrangements providing the setting for a very successful meeting.

The sessions were divided into two groups. At the Second Coating Conference it was suggested that the next meeting should be largely devoted to discussions on starch. Consequently, Norman Kennedy of the Corn Industries Research Foundation and James E. Bullard, Corn Products Sales Co., undertook the task of formulating a starch program. The other section was headed by F. E. Culp of the Consolidated Water Power and Paper Corp., Wisconsin Rapids, Wis. Under his guidance a number of papers of general interest were added to the program. Taken as a whole, the program presented at this conference was of universal interest to those

Increased use of the Corn Industry Viscometer by the starch manufacturers and the consumers of starch products has suggested further studies on the use of this instrument for the evaluation of raw and modified cornstarches. In particular, exhaustive studies have been made on the susceptibility of commercial cornstarches to enzymatic liquefaction. Studies were made using different conversion cycles and the viscosity or consistency changes were continuously recorded throughout the whole conversion period.

The viscosity charts suggest procedures that can be used to study the conversion characteristics of most commercial starches when subjected to variations in the concentration of the substrate, temperature, time, and pH.

It was found that converting at 20 to 25% starch solids, the conversion could be carried out satisfactorily using a continuous or a two-stage step-wise temperature increase during the converting range. However, at a high solids concentration of starch, such as 40 to 45%, it was necessary to use a four-stage step-wise temperature increase during the converting range.

Experimental evidence has been obtained showing that this instrument can be useful in detecting the converting characteristics of starches, which will enable the starch consumer to adjust for the differences in the various types of starches, before using the material in factory conversions for coating.

In the evening the Corn Industry was the host at a reception for the group attending the conference.

In the morning the program on starch continued in the form of a panel discussion with C. C. Kesler, Penick & Ford, Ltd., as moderator and the previous day's speakers for the panel. With the background of the previous day's papers, the group was in session the whole of the morning. It is expected that the formal presentations on starch will be published in full in the July, 1952, issue of *Tappi*.

Tuesday General Meeting

The meeting was turned over to F. E. Culp in the afternoon who introduced J. T. Loomer of the Robert Gair Co. The technical literature regarding coating is noteworthy in its lack of information on coating preparation. His paper, "Considerations in the Selection of Equipment for Coating Preparation," summarized in brief the factors governing the design and installation of a coating plant. The various sequences of methods used in coating preparation were discussed as well as the equipment used for their preparation. The information and discussions were considered from the aspect of the position of a mill contemplating a coating operation with an emphasis on the necessity of the TAPPI coating group to lay more stress on providing more information of an operating nature.

The next paper, "Large Scale Preparation of Clay Slips," by H. M. Hughson, Provincial Paper, Ltd., Port Arthur, Ont., and E. G. Heslop, Abitibi Power & Paper Co., Ltd., Sturgeon Falls, Ont., was presented by Mr. Hughson. The equipment and a method were described for preparing and handling clay slips in the 70% solids range. Coating clay received in bulk carload quantities is unloaded into a high-speed blunger where it is slurried with water previously measured into a large storage tank. Clay addition continues while the slurry is circulated through the blunger and the tank, until the entire carload of clay has been converted into slip. After final adjustment of solids content, the slip is screened and stored for use.

The experimental work leading to the design of the present system was discussed, with particular reference to the dispersing, pumping, and screening operations. Clay specifications and laboratory testing procedure were reviewed briefly.

The last paper on Tuesday, "Enzyme Treatment of Hi-Solids Starch-Pigment Mixtures," was presented by Jack E. Wilber, of the St. Regis Paper Co. The enzyme conversion of starch in the presence of pigments is recognized as a relatively new process of coating preparation that has gained commercial acceptance only recently. Many inherent advantages of the process were discussed as well as misconceptions regarding its disadvantages.

A commercial equipment installation was described followed by general procedures for preparing the slurry and converting the starch-pigment mixture. The many variables encountered were presented and procedures for eliminating and/or controlling them are outlined. An optimum cooking cycle and results obtained thereby were disclosed.

Design and construction of equipment utilized in laboratory studies and evaluations were illustrated. Time-temperature relationships, pigment adsorption characteristics, and viscosity characteristics during conversion as determined from laboratory studies were given.

Only principal features and high points were presented in order to promote a broader understanding of the process. The need for extensive laboratory development work is apparent in order to reduce operating variables to a minimum. Remaining variables are readily handled by production preparation procedures. The flexibility of the process allowing this manipulation is a primary asset ascribed to the system.

Printing Quality Symposium

The program for Wednesday, May 7, was introduced by a Symposium on the Evaluation of Printing Quality of Coated Papers. Mr. Culp, the chairman, introduced A. C. Zettlemoyer, Research Director, National Printing Ink Research Institute, and Professor of Chemistry, Lehigh University, Bethlehem, Pa., the first speaker. In his paper, "Numerical Evaluation of Letterpress Print and Printing Quality," Mr. Zettlemoyer presented a critical review of the problems involved and the methods previously proposed for measuring the properties which contribute to print and printing quality. Before the effect of variables in paper, ink, or press can be fully studied and appreciated, the end purpose, good print quality, must be defined and objective methods of quantitative evaluation found.

Print quality, or the faithfulness of the appearance of the print to the desired result, consists of properties such as uniform depth of color with proper finish in the solids and the reproduction of tones and contrasts halftone illustrations. The measurement of color is very complex, but reflectance, print-through, and gloss may be conveniently expressed in terms of intensity of reflected light. Attempts have been made to measure numerically uniformity of solids and tone reproduction and contrast of halftones; most workers, however, have relied on subjective evaluation as the final criterion of print quality.

A critical examination was also made of the methods proposed to measure the important variables contributed by the paper, ink, and press. It is recognized that those tests which duplicate actual printing practice give more reliable information. Printability of paper depends mainly on smoothness under printing pressure, ink receptivity, and surface bonding strength. The optical and working properties of an ink determine its printability. Working properties of an ink consist of viscosity, length, tack, and thixotropy, and these are often altered to suit the paper or the press. The finest paper and ink will still not produce a quality print if the press does not function properly, i.e., the printing pressure must be of the right magnitude and the plate must be made ready to give a uniform impression, etc.

The Printing Ink Research Institute's proposed program to study printability and related phenomena was discussed. Since the simplest situations can be most readily controlled and measured, the study of solids was undertaken first. Techniques are being worked out for the measurement of printing pressure and for the numerical evaluation of the uniformity of solids. After a thorough knowledge of solids

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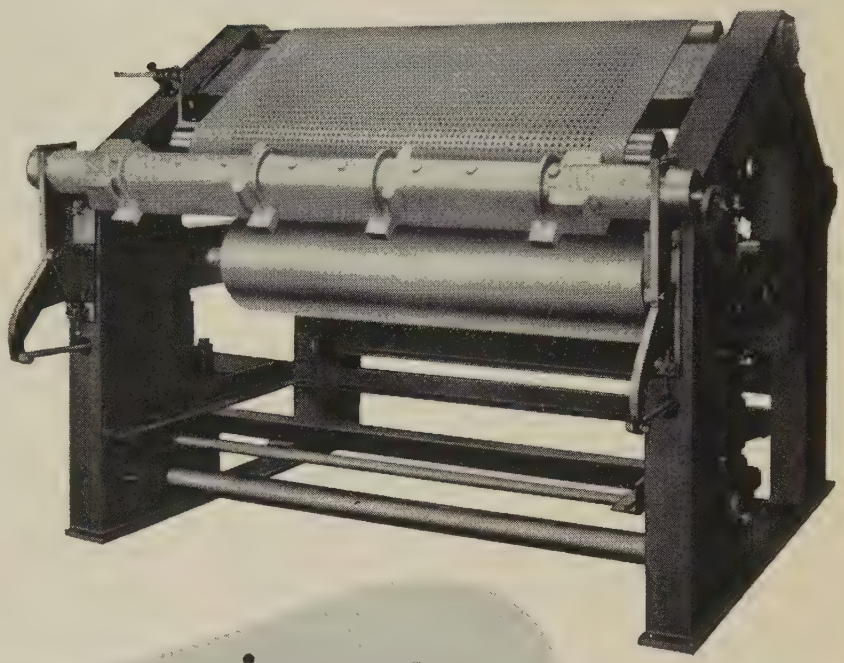

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has been obtained, the study of uniform halftones will be undertaken, followed by the printing of combinations of halftones of different densities. Ultimately this work should result in numerical evaluation of halftone pictures.

"The Toughest Job in the World," by R. C. Hydell of the Mead Corp., described the techniques and procedures which permit investigation of the individual contributions of raw-stock, coating formulation, and surface smoothness to the gravure printing qualities of coated paper. It was demonstrated that surface smoothness is the controlling factor in the faithful reproduction of light gravure tones, and that raw-stock and coating variables are important only insofar as they affect the surface smoothness of the supercalendered coated paper. However, ink and paper characteristics other than smoothness are of importance in the printing of solids and heavy tones. Consideration was given to coating formulation variables that are of importance, and to certain of the printing variables that affect the reproduction.

The last paper of the Symposium, "Evaluating Coated Surfaces for Lithography," was given by O. H. Somers, Western Printing & Lithographing Co. Application of the statistical method shows that ink receptivity, with results expressed as reflectance ratios between untreated and treated portions, is a reliable measure of ink cost on press, under stipulated conditions. Specification values can be selected and interpreted in terms of hold-up and drop-in.

Wettability by fountain solutions can be similarly treated, using a modified version of TAPPI Routine Control Method RC-49. Considerations relating to how wettable a coated paper should be were discussed and a control chart approach was shown.

A modified combination of these two tests shows that certain coated papers will accept less ink immediately after moistening, while in most cases the moistening does not influence ink receptivity. This is believed to be of substantial importance in relation to hold-up and trapping.

Results of an air-gage approach to smoothness measurement were reported.

This paper was followed by a panel discussion with the authors and W. H. Bureau, Chief Chemist, Butler Paper Corp., Chicago, Ill.; W. A. Kirkpatrick, Technical Director, Allied Paper Mills, Kalamazoo, Mich.; and J. F. Steinburner, Plant Manager, International Printing Ink, Chicago, Ill., constituting the panel.

Conference Luncheon

The Coating Conference Luncheon was held on Wednesday noon. After the chairman, Mr. Heuer, introduced the guests at the head table, he introduced Peter J. Massey, now a consultant located at River Forest, Ill. In his presentation, "New Horizons in Paper Coating," which will be published in the July issue of *Tappi*, Mr. Massey gave a very provocative summation of the prospects in the paper coating field.

Wednesday General Session

"A Rheological System for Analyzing the Flow Properties of Pseudoplastic and Thixotropic Pseudoplastic Materials," by R. N. Thompson and G. D. Hansen, Calgon, Inc., Pittsburgh, Pa., was the first paper of the last session. This paper presented a rheological system for the study of materials which exhibit pseudoplastic and thixotropic pseudoplastic flow. The basic assumption made in the development of this system is that the rate of shear applied in a rotational type viscometer must be varied exponentially to produce a unit change in the measured shearing force.

Equations are developed which permit the calculation of the amount of breakdown in structure of a pseudoplastic system due to both its pseudoplastic nature and to its thixotropy. From these derived constants a leveling index for pseudoplastic paper coating colors can be calculated.

The next paper was "Hot Resin Coated Papers as Barrier Material" by L. M. Burgess and L. F. Swec, of the H. P. Smith Paper Co., Chicago, Ill. Hot melt coated papers are old in the converting industry. Paraffin wax was originally used and subsequently was modified in many ways with film-forming plastics, resins, and plasticizers to increase the hardness and flexibility of the coating. Equipment limitations prevented the use of high viscosity coatings necessary for film toughness.

The commercial production of polyethylene introduced a relatively low viscosity, high film strength, uncompounded coating. The low molecular weights could be coated on existing equipment and the still greater film strength of the higher molcular weights directly led to the development of new coating technique.

Feeding the molten high molecular weight polyethylene to the coating unit was accomplished by using modified screw type rubber extruders. Factors involved in optimum extruder operation are discussed. Two methods of coating are hot resin coating and extrusion lamination which are briefly described. The advantage of hot resin coating is adhesion to the backing and versatility in coating various plastics. The advantage of extrusion lamination is lighter weight continuous coatings and lighter backings such as paper and aluminum foil. A comparison was made with older established procedures such as solvent coating and free film lamination.

The raw stock for coating must be carefully specified as to strength and finish in particular. The plastics used for coating require control of viscosity, stability, and physical form. Operation controls discussed are coating uniformity, coating continuity, and bond.

The important properties of six different polymers coated on paper were given. These polymers include polyethylene, saran, S-Polymer, cellulose acetate, nylon, and vinyl chloride-vinyl acetate copolymer. Saran, polyethylene, and S-Polymer coated papers are outstanding for water and water vapor resistance. Polyethylene is the best for low temperature flexibility. Heat sealability tests indicate that S-Polymer gives the greatest seam strength and is very easily sealed, although all these coated papers can be heat sealed. All the coated paper except polyethylene and S-Polymer have outstanding mineral oil resistance. Comparative results for gas and chemical resistance are given.

Coatings on aluminum foil and cotton fabrics were briefly discussed along with the major end use for all these products.

At the 37th Annual Meeting of the Association held in New York, a paper was presented on the new pick tester developed by the Lithographic Technical Foundation. The authors of that paper, Gordon C. Wheeler and Robert F. Reed, further discussed this instrument in their paper, "Pick Testing of Offset Papers." A brief description was given of (1) the LTF pick tester, (2) the press conditions that a pick tester should simulate, and (3) the reasons why these conditions should be simulated.

The press condition of greatest importance in picking is the velocity of separation of ink and paper normal to the paper surface. The reason is that the energy absorbed by the paper influences picking tendency an amount depending on this velocity. The importance of this factor was illustrated by correlation coefficients between a press test and (1) the LFT pick tester and (2) the Dennison waxes. Coefficients for papers of widely varying caliper were compared with papers having the same thickness. The wax test was not considered satisfactory.

The influence of some variations in the strength of the base stock and adhesive compositions on the pick resistance of coated paper was discussed.

The plant visits on Thursday, May 8, concluded the conference. Because of its obvious success, which was due to the wholehearted cooperation of all who were concerned, it is hoped that next year it will be possible to hold the Fourth Coating Conference.

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PERSONAL MENTION

Items About New and Old Tappimen

New TAPPI Members

Joseph Abelson, Student, New York State College of Forestry, Syracuse, N. Y.

Robert G. Adams, Senior Chemist, Provincial Paper Ltd., Port Arthur, Ont., Canada, a 1949 graduate of Queen's University.

Henry F. Bayges, Vice-President, Star Corrugated Box Co., Inc., Maspeth, L. I., N. Y., a 1940 graduate of New York University.

Alfred G. Battaglia, Supervisor, Lacquer Development, National Starch Products, Inc., New York, N. Y., a 1943 graduate of Manhattan College.

John W. Brooks, Student, New York State College of Forestry, Syracuse, N. Y.

John C. Brown, Plant Superintendent, J. W. Clement Co., Buffalo, N. Y.

Dwayne S. Burak, Assistant to Pulp Mill Superintendent, Escanaba Paper Co., Escanaba, Mich.

Ralph W. Burdeshaw, Southern Sales Manager, Plaskon Div., Libbey-Owens-Ford Glass Co., Charlotte, N. C.

Philip A. Cerasoli, Student, New York State College of Forestry, Syracuse, N. Y.

William M. Cranston, Engineer, Western Printing & Lithographing Co., Poughkeepsie, N. Y., a 1943 graduate of the University of Michigan.

Mrs. J. Henry Crosland, Librarian, Georgia Institute of Technology, Atlanta, Ga., a 1923 graduate of Emory University.

Pierre A. Dreyfus, General Manager, CARFA Ltd., Zurich, Switzerland.

Jean E. A. Dupont, Papermaking Consultant, San Sebastian, Spain.

Charles L. Eddy, Technologist, American Can Co., Newark, N. J., a 1947 graduate of Providence College.

Leslie M. Faichney, Assistant Chief, Standards and Measurements Group, Pulp and Paper Research Institute of Canada, Montreal, P. Q., Canada, a 1946 graduate of McMaster College with an M.Sc. degree.

Christian J. Fauth, Jr., Service Engineer, Plaskon Div., Libbey-Owens-Ford Glass Co., Milwaukee, Wis.

Aloysius J. Felton, District Sales Engineer, Black-Clawson Co., Fulton, N. Y.

Joel D. Ferry, Sonoco de Mexico, S. A., Mexico, a 1941 graduate of Stanford University.

Gaston Francoeur, Principal, École de Papeterie, Three Rivers, P. Q., Canada.

Joseph E. Frederick, Chemist, Ozalid Div., General Aniline & Film Corp., Johnson City, N. Y., a 1937 graduate of the University of Iowa.

Melvin F. Goyke, Engineering Dept., Thilmany Pulp & Paper Co., Kaukauna, Wis.

John A. Gregg, Director of Quality Control, S. Curtis & Son, Sandy Hook, Conn., a 1950 graduate of New York University.

Gerald A. Hale, Student, Western Michigan College, Kalamazoo, Mich.

Laura T. Hall, Research Chemist, Kendall Mills, Research Laboratories, Paw Creek, N. C., a 1936 graduate of the University of North Carolina with a Ph.D. degree.

Burnett Q. Haynes, Manager, Mullen Tester Div., B. F. Perkins & Son, Inc., Holyoke, Mass., a 1934 graduate of Northeastern University.

Robert B. Hobbs, Acting Chief, Paper Section, National Bureau of Standards, Washington, D. C., a 1941 graduate of George Washington University.

James W. Jelks, Sales, Denver Equipment Co., Denver, Colo.

William H. Kibbel, Jr., Technical Sales Representative, Becco Sales Corp., Buffalo, N. Y., a 1947 graduate of Case Institute of Technology with an M.S. degree.

John G. Kressman, Head, Adhesives and Wax Section, Research Dept., Dixie Cup Co., Easton, Pa., a 1943 graduate of the University of Illinois.

Howard C. Lee, Assistant Chief Engineer, Canadian International Paper Co., Montreal, P. Q., Canada, a 1928 graduate of Northeastern College.

Lawrence M. Liggett, Research Supervisor, Wyandotte Chemicals Corp., Wyandotte, Mich., a 1943 graduate of Iowa State College with a Ph.D. degree.

James A. Mann, Research Supervisor, A. B. Dick Co., Chicago, Ill., a 1940 graduate of Rensselaer Polytechnic Institute.

M. Margerie, Hachette Library, Paris, France.

Norval Magnusson, Chemical Engineer, Puget Sound Pulp & Timber Co., Bellingham, Wash., a 1948 graduate of the University of North Dakota.

Hisato Murata, Assistant Laboratory Manager, Asahi Electro-Chemical Co. Ltd., Tokyo, Japan, a 1935 graduate of Kyushu University.

Henry C. Pan, Assistant Engineer, Union Bag & Paper Corp., Savannah, Ga., a 1951 graduate of North Carolina State College with an M.S. degree.

Edward G. Paxton, Jr., Senior Research Engineer, Dilts Machine Works, Fulton, N. Y., a 1931 graduate of Virginia Military Institute.

Vincent Pessolano, Director of Ceprano and Atina's Paper Mills, Ceprano, Italy, a 1937 graduate of the University of Naples with a Ph.D. degree.

Carl F. Pihl, Student, Lowell Textile Institute, Lowell, Mass.

Donald E. Read, Research Chemist, Canadian Industries Ltd., Montreal, P. Q., Canada, a 1945 graduate of Mount Allison University with a Ph.D. degree from McGill University in 1949.

William J. Rhine, Assistant Superintendent, Star Corrugated Box Co., Inc., Maspeth, L. I., N. Y.

John D. Ryan, Chief of Quality and Production Control, Star Corrugated Box Co., Maspeth, L. I., N. Y. Attended Brooklyn College.

Ewald Schoeller, President, Ewald Schoeller & Co., Zurich, Switzerland.

James B. Smith, Sales Engineer, Esso Standard Oil Co., New York, N. Y., a 1943 graduate of Virginia Polytechnic Institute.

Georges Soules, President and General Manager, Societe des Cartons Industriels, Paris, France, a 1906 graduate of Lycee Charlemagne.

Harold D. Stuck, Vice-President, John W. Bolton & Sons, Inc., Lawrence, Mass. Attended Lowell Institute.

Arnold R. Sundholm, Mill Manager, Wartsila-Cellulose A/B, Aanekoski, Finland, a 1932 graduate of the Technical University, Finland.

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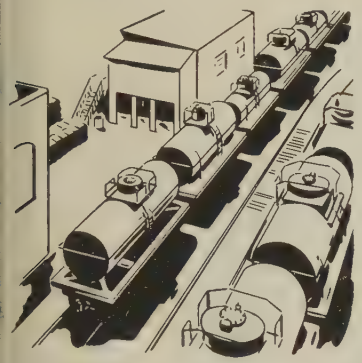

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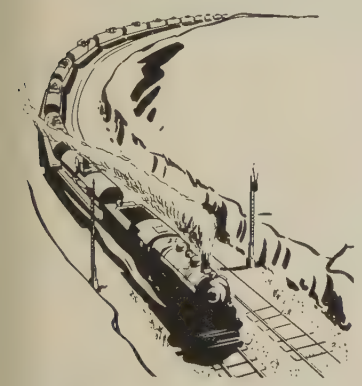

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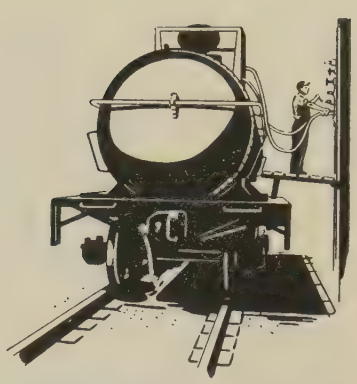

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- 201 Process and Equipment for Making Bleach Liquor for Use Without Settling
- 211 Chemistry of Bleaching Chemical Wood Pulps
- 214 What Do We Know About Bleaching?
- 236 Importance of pH and Catalysts in Bleaching Operations
- 242 Production and Use of Unsettled Bleach Liquor
- 243 Procedures and Brightness Grades in Bleaching Sulfate Pulps

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Allen M. Taber, Technical Service Representative, E. I. du Pont de Nemours & Co., Inc., Boston, Mass., a 1932 graduate of Rice Institute of Technology.

Fred W. Thiem, Engineer in Charge of Maintenance, The Hoerner Corp., Keokuk, Iowa.

William S. Thornhill, President, U. S. Polymeric Chemicals, Inc., Stamford, Conn., a 1935 graduate of Lafayette College.

H. Dale Turner, Chemical Engineer, Forest Products Laboratory, Madison, Wis., a 1938 graduate of Iowa State College.

Richard I. Van Buren, Research Engineer, Dilts Machine Works Div., Black-Clawson Co., Inc., Fulton, N. Y., a 1949 graduate of Michigan State College.

Charles E. Walker, Sales Engineer, Plaskon Div., Libbey-Owens-Ford Glass Co., Boston, Mass.

Robert D. Weant, Service Engineer, Plaskon Div., Libbey-Owens-Ford Glass Co., High Point, N. C.

John E. Webb, General Superintendent, Sonoco de Mexico, S. A., Mexico, D. F., Mexico, a 1947 graduate of Clemson College.

Robert S. Williams, Chemical Engineer, Marathon Corp., Menasha, Wis., a 1949 graduate of Texas A & M College.

Robert E. Woodhams, Patent Lawyer, Lawrence, Woodhams, Mills and Price, Kalamazoo, Mich., a 1934 graduate of the University of Michigan.

Robert A. Worden, Materials Engineer, General Electric Co., Coshocton, Ohio, a 1949 graduate of the University of Wisconsin.

Donald O. Wynocker, Sales, Plaskon Div., Libbey-Owens-Ford Glass Co., Toledo, Ohio. Attended the Colorado School of Mines and Bowling Green State University.

Henry R. Young, Industrial Sales, Finishes Div., E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., a 1937 graduate of Harvard University.

George J. Zelenka, Manager, Papermaking Research Institute, Prague, Czechoslovakia, a graduate of the College of Industrial Chemistry, Prague.

TAPPI Notes

R. Ellsworth Annis, Jr., formerly of the Fitchburg Paper Co., is now Design Engineer for the Improved Paper Machinery Co., Nashua, N. H.

Arthur Aronoff, formerly of the Ashland Paper Mills, is now in charge of pulp processing for APW Products, Inc., Albany, N. Y.

Carl A. Briggs, of the Sales Dept., Fraser Paper Ltd., has transferred from New York City to the Chicago office.

W. F. Boucher, Research Associate for Lever Bros. Co., has transferred from Cambridge, Mass., to Edgewater, N. J., where the Research Div. is now located.

Harold Y. Charbonnier is now Assistant Manager of the Pulp and Paper Div. of the Union Bag & Paper Corp., Savannah, Ga.

Raymond T. De Pan, formerly of the Downingtown Mfg. Co., is now Sales Engineer for the Sandy Hill Iron & Brass Works, Hudson Falls, N. Y.

H. A. DesMarais, formerly of the General Dyestuff Corp., is now General Sales Manager for Pennsylvania Salt Mfg. Co., Tacoma, Wash.

Sydney O. Edge is now Works Manager of John Wild & Sons, Ltd., Radcliffe, England.

John A. Feola, formerly of the Ohio Boxboard Co., is now Chief Chemist for Morris Paper Mills, Morris, Ill.

E. C. Gates is now Vice-President and Director of the Crossett Lumber Co., Crossett, Ark., and Executive Vice-President of Fordyce Lumber Co., Fordyce, Ark.

William F. Gerrow, Jr., formerly of the Fulton Bag & Cotton Mills, is now Special Representative for Goodyear Tire & Rubber Co., Chemical Div., Decatur, Ga.

Kenneth E. Glidden is now General Manager of the Celon Co., Muscatine, Iowa.

Leonard R. Growdon is now Vice-President in Charge of Board Operations, Mead Corp., Chillicothe, Ohio.

G. A. Gyllenhoff, Technical Consultant for Elaf Hansson Co. has transferred from Montevideo, Uruguay, to São Paulo, Brazil.

C. E. Hartford, formerly of the Union Bag & Paper Corp., is now Vice-President and Resident Manager of Riegel Carolina Corp., Acme, N. C.

Thomas C. Johnson is now General Operating Superintendent of the Pulp and Paper Div. of the Union Bag & Paper Corp., Savannah, Ga.

John R. Lientz is now General Manager of the Pulp and Paper Div., Union Bag & Paper Corp., Savannah, Ga.

Harold L. Jones, formerly Research Associate of The Institute of Paper Chemistry, is now Research Chemist for the Southern Kraft Div., International Paper Co., Mobile, Ala.

Glenn C. Kimble is now Assistant Technical Director for Union Bag & Paper Corp., Savannah, Ga.

Frank S. McCall is now Superintendent of the Factory Technical Dept., Union Bag & Paper Corp., Savannah, Ga.

Harry C. Moore is now President of the Beloit Iron Works, Beloit, Wis.

Elbert H. Neese is now Chairman of the Board of Directors, Beloit Iron Works, Beloit, Wis.

George H. Pringle, formerly Chief Engineer, is now Vice-President in Charge of White Paper Operations, Mead Corp., Chillicothe, Ohio.

J. C. Pullman is now Technical Representative, New Product Development Dept., American Cyanamid Co., New York, N. Y.

Robert M. Schneble, formerly of Coosa River Newsprint Co., is now Branch Manager, The Foxboro Co., Jacksonville, Fla.

J. P. Sermattei, Research Chemist for E. I. du Pont de Nemours & Co., Inc., has transferred to the du Pont Marshall Laboratory, Philadelphia, Pa.

Chester N. Stupp is now Manager of Sales Service, Oxford Paper Co., New York, N. Y.

Frank J. Spinar, formerly with U. S. Army, is now with the Engineering Div., Japan Procurement Agency, Yokohama, Japan.

Luis R. Troncoso, Chemist for Cia. Ind. de Atenquiqui, has transferred from Atenquiqui to Guadalajara, Jalisco, Mexico.

Charles E. Van de Carr, formerly President, is now Director of Engineering and Chairman of the Engineering and Development Committee for the Mead Corp., Chillicothe, Ohio.

Howard E. Whitaker is now President of the Mead Corp., Chillicothe, Ohio.

C. Frederick Young, formerly of the Rising Paper Co., is now Technical Director for the Monadnock Paper Mills, Inc., Bennington, N. H.

* * *

J. L. Ober, Vice-President in charge of Research and Development, has succeeded *Paul C. Baldwin* as the official corporate representative of the Scott Paper Co., Chester, Pa., in TAPPI.

* * *

E. S. Le Baron, Assistant General Sales Manager, has succeeded *W. A. Montgomery* as the official representative of John Inglis Co. Ltd., Toronto, Ont., in TAPPI.

* * *

Martin Sundell, Superintendent of Holmens Bruks & Fabriks A/B, Norrkoping, Sweden, and *Bertil W. Svarson*, of the Swedish Forest Products Research Laboratory, Stockholm, Sweden, were recent visitors to the pulp and paper mills in the United States.

HAM FELTZ says:

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Industry Notes

Production

The paper and board production for the first quarter of 1952 was about 6,183,000 tons. This sets an annual rate for 1952 of 24,732,000 tons which compares with 26,086,115 tons for 1951. Production for the first quarter is 8% below the volume that prevailed in the first quarter a year ago.

Set-Up Box Industry

The Federal Trade Commission, Washington 25, D. C., has released set-up paper box industry trade practice rules (FTC File 21-153).

Red Deer, Alberta

International Resources, Ltd., a firm backed by Seattle businessmen, and the Alberta provincial government expect to build a pulp mill at Red Deer, Alberta. The plant will manufacture groundwood, chemical and/or semichemical pulp and will cost about 5 million dollars. Construction must begin by July 1, 1953, and be completed by Oct. 1, 1954. Products will be available for export until April 1, 1962, when the firm must start and complete in 15 months mill extensions that will make no further export of pulp necessary. The firm will then process the pulp into paper products in Alberta. The government must be paid $15,000 a year in timber taxes, $4000 a year in ground rent, and a minimum royalty of $15,500 a year.

Certificates

Through February, Certificates of Necessity have been approved for: 36 pulp mills ($316,842,000 at 56.8%); 43 paper mills ($235,160,000 at 49.5%); 3 paper coating and glazing plants ($6,135,000 at 36.8%); 1 paper bag plant ($59,000 at 49.2%); 3 paperboard, box, folded, set-up, and corrugated plants ($3,765,000 at 48.5%); 4 fiber cans, tubes, drums, etc., plants ($2,947,000 at 53.5%); and 2 converted paper products plants ($39,000 at 67.6%).

Pending are Certificates for: 37 pulp mills ($233,610,000); 75 paper and board mills ($217,932,000); 11 paper coating and glazing plants ($5,269,000); 1 envelope plant ($115,000); 6 paper bag plants ($17,326,000); 8 paperboard, box, folded, set-up, and corrugated plants ($11,225,000); 2 fiber cans, tubes, drums, etc., plants ($5,945,000); and 25 converted paper products plants ($53,179,000).

Freight Rates

All basic freight rates were increased on May 2 by 15%. This increase was applied as a percentage increase in the amount of total freight charges as shown by the freight bill exclusive of the 3% Federal transportation tax and is in lieu of the former surcharges of 9% within Eastern territory and 6% elsewhere which have been in effect since Aug. 28, 1951.

Line haul rates on anthracite coal, bituminous coal (except lignite) and coke, in carloads may be increased 12% to, from, and within all territories, subject to a maximum of 40 cents per ton. The authority to maintain these increases is to expire Feb. 28, 1954, unless sooner modified or terminated by the Interstate Commerce Commission (Decision of April 11, 1952, in *Ex Parte* 175 (and Sub. No. 1).

New Zealand

The first kraft pulp and paper mill in New Zealand is under way at Kinleith. It is expected to produce pulp about the middle of 1953. Initial production will be 25,000 tons to be increased later to 45,000 tons. A kraft paper mill with annual production of 15,000 tons will operate in conjunction with the pulp mill. The mill is expected to be able to supply almost all the heavy wrapping needs of New Zealand and allow for exporting sulphate pulp to Australia.

Nitrating Wood Pulp

The new ceilings for bleached sulphite, nitrating grade, is $170 per ton; bleached sulphate pulp is $175 per ton. Heretofore manufacturers could determine individuals on these grades by application to OPS. Nitrating pulp is a special grade used to make such nitrated cellulose products as lacquers, paints, plastics, blasting powder, and smokeless powder. The new ceilings were established at the request of the Munitions Board to facilitate military procurement.

The ceiling on the nitrating grade of bleached sulphite pulp is fixed at $30 a ton higher than the ceiling of $140 spelled out for the papermaking grade of bleached sulphite when CPR49 was issued on June 25, 1951.

Currently, no nitrating grade of bleached sulphate is made, but the Munitions Board has a research program under way to develop production of this grade. The ceiling for nitrating sulphate pulp is established at $5.00 a ton higher than the ceiling for the bleached sulphite grade, maintaining the differential existing between bleached sulphate and bleached sulphite papermaking grades.

Clay and Tracy

John C. Clay has been appointed Director of the Containers and Packaging Div. of the NPA by Lawrence W. Strettner, Assistant Administrator for the Chemical, Rubber and Forest Products Bureau. Mr. Clay is on leave as Assistant to the Executive Vice-President of National Starch Products, Inc., New York, N. Y.

Lyall Tracy of Rayonier, Inc., Aberdeen, Wash., was appointed Director of the Pulp, Paper and Paperboard Div., NPA. Mr. Tracy succeeds John W. Maloney, Vice-President of Hoberg Paper Mills.

Accelerated Amortization

The following additional Certificates of Necessity have been granted in the first five months of 1952: Everett Pulp & Paper Co., Lowell, Wash. ($2,940,000 at 45%); Hoberg Paper Mills, Green Bay, Wis. ($2,215,000 at 40%); Crown Zellerbach Corp., Camas, Wash. ($320,270 at 40%); Hudson Pulp & Paper Co., Augusta, Me. ($225,446 at 40%); Oxford Paper Co., Rumford, Me. ($1,200,000 or less at 35%).

Southern Paperboard

The Southern Paperboard Corp. has issued $9,300,000 of 4% first mortgage bonds, due 1970, to the Mutual Life Insurance Co. The loan was made to consolidate the company's funded debt to a single issue, and to provide funds for plant additions and improvements which will increase the yield of kraft paperboard per cord of wood, and the capacity of its mill at Port Wentworth, Ga.

Chase Bag

Walter J. Wilks has been appointed Manager of the Chase Bag Co.'s Chagrin Falls, Ohio, paper mill. Harry S. Pedley succeeds Mr. Wilks as superintendent.

Paterson Parchment

A. J. Vreudenberg, Chief Engineer of the Paterson Parchment Paper Co., Bristol, Pa., has announced that the Mahony-Troast Construction Co. will start construction of two projects that will greatly enlarge their plant facilities. These consist of a new 52 by 52 by 29-foot coagulator and a new 58 by 32-foot filter bed. Six hundred cubic yards of concrete will be used for the coagulator; 170 cubic yards will be required for the filter bed. Sixteen weeks will be required to complete the job. A unique construction method will be employed. The equivalent of about 100 truckloads of concrete must be poured continuously to achieve monolithic form for the coagulator.

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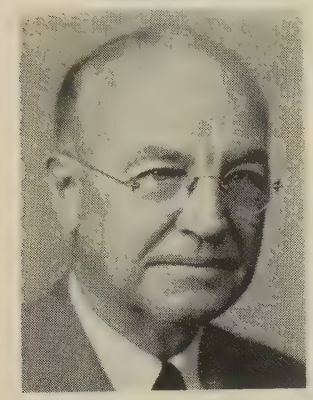
Mead

Charles R. Van de Carr, Jr., has retired as President of the Mead Corp., Chillicothe, Ohio, but will continue with the company as Director of Engineering and Chairman of the Engineering and Development Committee. He is the inventor of the Van de Carr slice used on high-speed paper machines.



Charles R. Van de Carr, Jr.

Howard E. Whitaker

Mr. Van de Carr is succeeded as President by Howard E. Whitaker. Donald F. Morris was elected First Vice-President. George H. Pringle, former Chief Engineer, was elected Vice-President in Charge of White Paper Operations. Mr. Pringle is Vice-President of the Technical Association of the Pulp and Paper Industry. Leonard R. Growden was advanced to become Vice-President in Charge of Board Operations. Ford T. Shepherd was elected Vice-President in Charge of Corporate Relations.

Other executives re-elected were: George H. Mead, Chairman of the Executive Committee, Sydney Ferguson, Chairman of the Board, Alan G. Goldsmith, Herbert A. Kidd, A. H. Mahrt, H. T. Mead and R. H. Savage, Vice-Presidents, Murray Smith, Secretary, and George Robinson, Treasurer.

Cyrus N. Mull was appointed Chief Engineer to succeed Mr. Pringle. Walter Hall was appointed Power Engineer and E. J. Fadden was appointed Chief Project Engineer.

Technical Society Standards

Willis S. MacLeod, Director of the Standards Div., Federal Supply Service, GSA, has announced that the Federal Government and the military services will now use nationally recognized industry and technical society standards to the maximum extent possible in developing Federal and military specifications and standards.

Public law 152, recommended by the Hoover Commission, has given the General Services Administration over-all responsibility in the whole area of standardization without regard to type of material, supplies, or equipment. One element of the statute gives official sanction to participation by Government agencies in the work of "approved industry groups."

R and D Costs

The *Wall Street Journal* reports that the Internal Revenue Bureau "won't split hairs" over deduction of research and development costs, as long as they represent costs in experimental or laboratory sense. However, amounts paid out for new buildings and equipment adaptable for use other than the particular research project for which they were constructed must be capitalized.

Paper Thermometer

Paper thermometers have been developed by the Army Quartermaster Corps. A thermal indicator consists of white pigment coated on black paper. At designated temperature (range of 115 to 500°F.) the white coating melts, disappears into porous paper, and reveals black background.

Research Climate

W. F. Rockwell, Jr., President of the Rockwell Mfg. Co., Pittsburgh, Pa., advises that the ways to provide a proper climate for research are as follows: (1) furnish good direction, (2) offer adequate compensation, (3) supply adequate facilities and good working conditions, (4) have patience, and (5) give the research director a reasonably free hand. He warns against plans to do things that others should do and urges executives to look into outside research services. He suggests the choice of sufficient problems with a good chance of solution for the benefit of researchers' morale.

Copying Paper

Minnesota Mining & Mfg. Co. now makes a copying paper called Thermo-Fox. It is a paper with a heat-sensitive and colored backing. On placing the paper in contact with material to be copied and exposing it to infrared light, the coating melts opposite dark portions and permits the backing to show through.

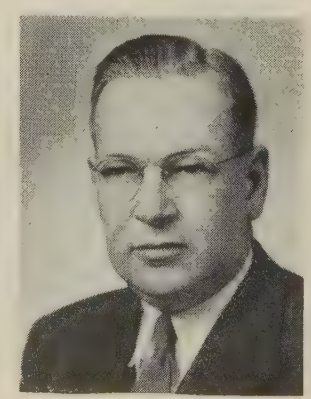
Brinkerhoff

H. E. Brinkerhoff, Executive Secretary of the American Pulpwood Association for the past 13 years, will retire on July 1. He was succeeded on May 1 by W. S. Bromley who has been with the Association for the past 3 years.

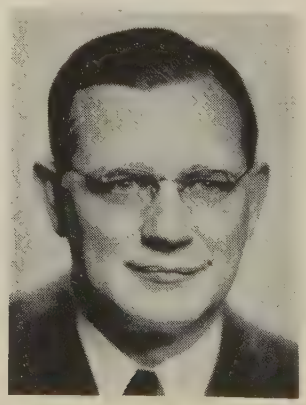
Kilowatts

Today, the United States has an installed electric generating capacity of about 76 million kilowatts. Should the trend of expansion continue during the next ten years, as it is expected to do, generating capacity will be doubled at the end of the

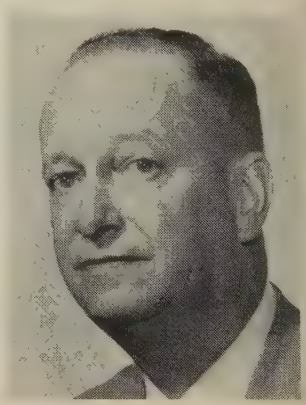
Donald F. Morris



George H. Pringle

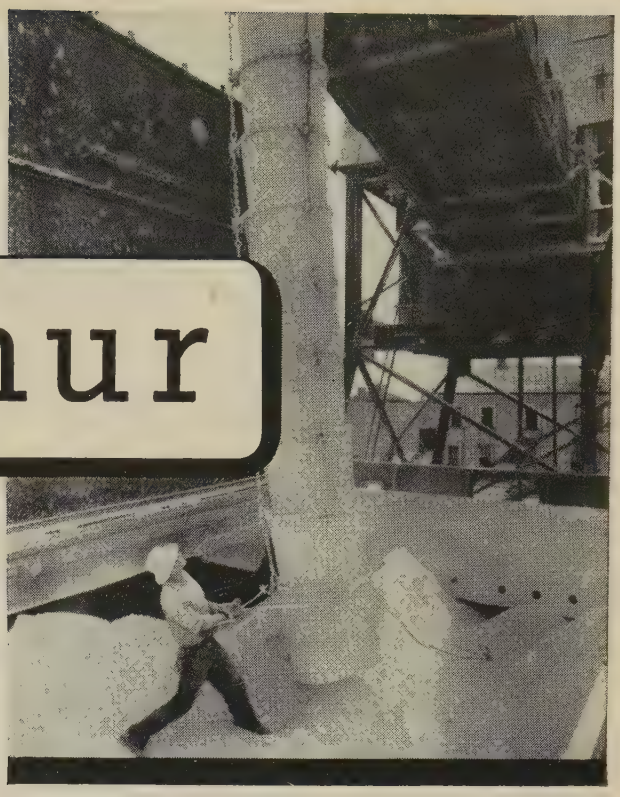


Leonard R. Growden



C. N. Mull

Sulphur

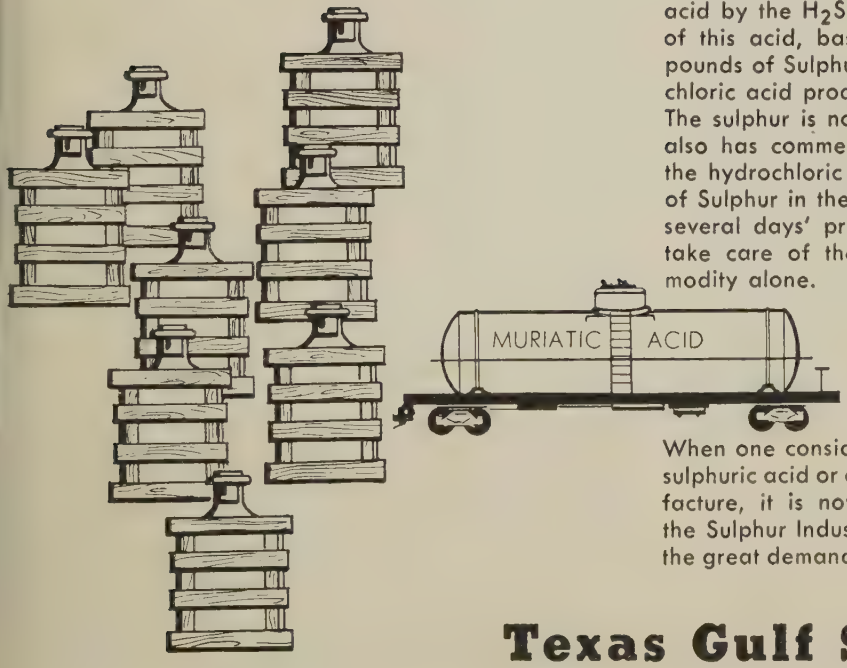


Loading a ship with Sulphur at Galveston

Thousands of tons mined daily, but where does it all go?

PARAPHRASING an old saying: 'It takes a chemical to make a chemical,' certainly applies to hydrochloric acid.

No chemical engineer has to be told how hydrochloric acid is made but sometimes with the mind focussed on the word "hydrochloric" little thought is given to another word "sulphuric." It is this word that calls attention to the fact that to make one net ton of 20° Bé hydrochloric acid by the H_2SO_4 process requires about 950 pounds of this acid, basis 100%, which is equivalent to 320 pounds of Sulphur. About one third of the annual hydrochloric acid production is made by the use of sulphuric. The sulphur is not lost because salt cake, a by-product, also has commercial value. But any way you figure it, the hydrochloric acid industry is an important consumer of Sulphur in the form of sulphuric acid. In fact, it takes several days' production from all the Sulphur mines to take care of the annual production of this one commodity alone.



When one considers all the other chemicals that require sulphuric acid or other Sulphur compounds for their manufacture, it is not difficult to appreciate how faithfully the Sulphur Industry is serving industry today in spite of the great demands made upon it.

Texas Gulf Sulphur Co.

75 East 45th Street, New York 17, N. Y.

Mines: Newgulf and Moss Bluff, Texas

decade. Last year, 105,682,000 tons of coal were used to generate electricity, an increase of 15% over 1950.

Labor Consultant

Albert W. Luhrs, Executive Manager of the National Paperboard Association and the Fibre Box Association, Chicago, Ill., has announced the appointment of Thomas J. Cleland as a Labor Consultant for the Association. He will serve with Finley F. Bell. During the past 10 years Mr. Cleland has been employed as a Commissioner in the Federal Mediation and Conciliation Service in Chicago.

Wastepaper

In the 6 years from Jan. 1, 1946, to Dec. 31, 1951, 47,531,000 tons of wastepaper were recovered in the United States, processed, baled, and sold to the wastepaper consuming mills of this country and sold for export to other countries. Of this total recovery, only 825,517 tons, or about 1.8%, were exported. This exported wastepaper was sold for approximately $35,500,000, or an average of a shade over $41.70 per ton. Source: Department of Commerce reports.

Of the total tonnage of wastepaper exported in the 6 years, 313,693 tons consisted of the news grades, chiefly folded and overissue news, specially packed in burlap and securely bound with steel strapping. It represented 38% of the tonnage exported, and in many instances was shipped to the Far East to be used for wrapping paper. The remaining 62% included all other grades of wastepaper of which a considerable amount of old corrugated boxes and high grades were shipped abroad.

Our Canadian neighbors were the best customers of the United States for wastepaper during the 6 years, almost one third of all our exports of paper stock having been shipped across our Northern border. Of a total of 260,135 tons of wastepaper exported to Canada, only 26,355 tons were news, the other grades, including corrugated and pulp substitutes, being in greater demand. Canada's demands for wastepaper were greater last year, just as in the United States, and 68,800 tons of our total exports of 206,438 tons were shipped to the Dominion.

During the 6 years, almost 5% of the total wastepaper exports went across our Southern border into Mexico for a total of 39,705 tons, less than 600 tons of which was news. Mexico's wastepaper demands were greater last year than the five previous years combined. Shipments amounted to 21,400 tons in 1951.

Although France is not recorded as having received any wastepaper from the United States in 1950, well over 100,000 tons were shipped from 1946 to 1951, inclusive, one third of which was news and two thirds the other grades. Fifty thousand tons of wastepaper were exported to France from the United States in 1948. Last year's shipments amounted to 18,273 tons of all grades.

Exports to some of the other countries last year included the following: British Malaya 21,364 tons, Philippine Republic 14,833 tons, Hong Kong 14,388 tons, Netherlands Indies 11,224 tons, Thailand 6180 tons, Cuba 5310 tons, Germany 5071 tons, Australia 2651 tons, Netherlands 2390 tons, United Kingdom 1856 tons, Belgium 1287 tons, Austria 1236 tons, Venezuela 1006 tons, Peru 601 tons, Columbia 594 tons, Japan 491 tons, Switzerland 489 tons.

Eastern dealers report that while shortages of wastepaper exist in many foreign countries, dollar shortages in those countries prevent them from buying much in the United States. However, during the early part of the year the export trade had been fairly good to some countries. Little, if any, is going to Canada at the present time because the supply there appears to be adequate for current requirements. Little news goes into Mexico on account of the high import duty imposed by that country. Plenty of wastepaper is available to export, as for domestic consumption, but world as well as national demands are quiet.

Consolidated at Interlake

Two all-time high records have been broken in the pulp and paper industry's program to find ways for using sulphite liquor to keep it out of Wisconsin streams. A few weeks ago the experiment furnace at Interlake Mill of Consolidated Water Power and Paper Co. completed its thirtieth full day test-burning spent sulphite liquor as industrial fuel. Earlier in the day the total of liquor consumed in these tests passed 1,000,000 gal. Both of these are new high marks to the credit of the Wisconsin sulphite research program.

Engineers and scientists originally believed that even after spent sulphite liquor of the usual 10 to 12% solids content was condensed to 50–50 solids and water, it could not support combustion unless burned along with some other fuel such as oil or powdered coal. Experiments conducted in an old furnace at Interlake Mill proved that under proper conditions the condensed liquor can be burned alone.

So Consolidated engineers last Summer built a test furnace of special design and have been experimentally operating it off and on to determine how to use sulphite liquor efficiently for fuel. In between burning tests, they rebuild the furnace, change its equipment, try different concentrations of liquor, or otherwise vary the operating conditions as indicated by previous runs. Data yielded by these experiments are being used in designing the new boiler which eventually will burn the mill's output of spent liquor.

Tests now being conducted are principally to determine the right size of burner to make good use of the most fuel, and to reduce the ash escaping from the stack. Scheduled for early installation on the experimental unit are an air preheater, a dust collector, and an induced draft fan. Company engineers' goal is to have everything working smoothly by the time that the mill gets its stainless steel evaporator equipment that has been delayed by defense shortages.

Technical experts of the Sulphite Pulp Manufacturers' Research League know of no other U. S. mill that has burned as much calcium-base spent sulphite liquor or that has operated a furnace for so many days using this fuel. Condensed liquor for Interlake's burning tests has been produced in the League's pilot evaporator plant here, the only evaporator in the state capable of handling this industry by-product.

Student Mill Tour

Twenty-one senior and graduate students of pulp and paper at State University of New York, College of Forestry at Syracuse, accompanied by three faculty members, made first-hand study of manufacturing operations in five Canadian mills May 6–9. The week-long tour by bus began with visits to Bagley and Sewall Co., Watertown, N. Y., makers of paper mill equipment, and National Paper Products Co., Carthage, N. Y., tissue products, on May 5.

Then to give the students a close look at a variety of Canadian mill operations, the following industries were visited beginning May 6:

Howard Smith Paper Mills Ltd., Cornwall, Ont., Dr. G. H. Tomlinson, Research Director, host
E. B. Eddy Co., Hull, Que., Eric Norman and C. E. Davies, hosts
International Fibre Board Ltd., Gatineau, Que., D. E. Read, Manager, host
Kenwood Mills Ltd., Arnprior, Ont., Kirke Dunlap, Superintendent, host
Canadian International Paper Co., Gatineau, A. W. Simpson, Manager, host

All the students in the group were New York State residents except three, who are from Spain, Paraguay, and Norway, and are graduate students. They all made reports of their trip to satisfy one of the final requirements of the curriculum in pulp and paper manufacture at the College of Forestry.

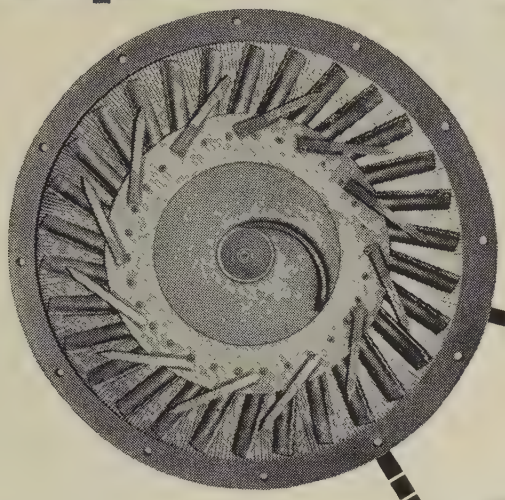
Faculty members on the trip were Profs. C. Peter Donofrio, Robert G. Hitchings, and S. Earl Church.

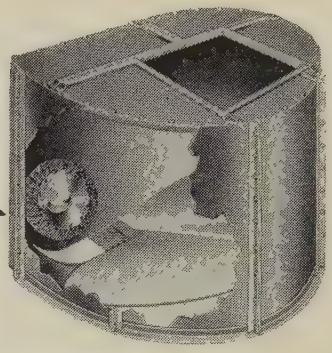
PRESENTING

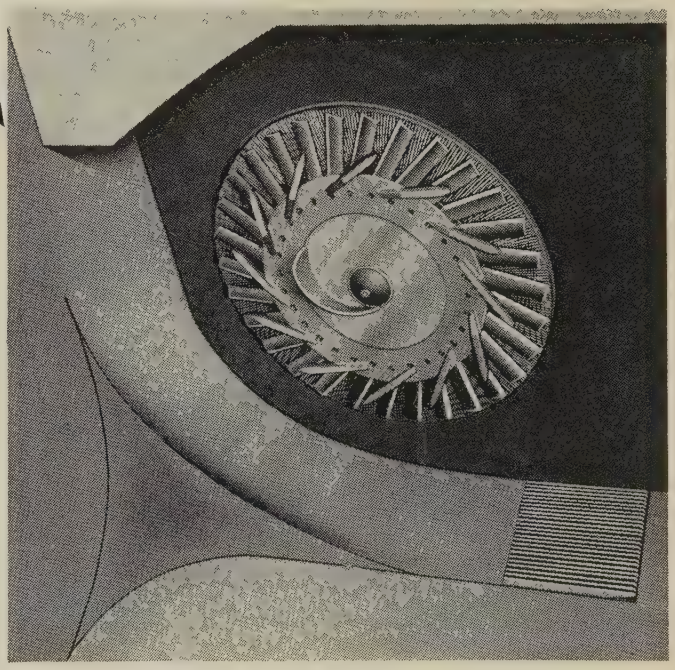
the new Cowles BEATAPULPER

It Pulps, Defibers, Refines

IN ONE OPERATION







FOR THE FIRST TIME, one machine will pulp, defiber and refine all your paper stock. Here's what happens when this high-speed refiner goes to work in the pulper tub:

● IT PULPS

The BEATAPULPER is its own pulper. There's no need to baby this machine. You furnish whole bales at once — the unit takes them in stride and slushes them in minutes.

● IT DEFIBERS

The Cowles BEATAPULPER completely defibers the toughest furnish in amazingly short cycles. You'll find no "eyes" or specks in the sheet.

● IT REFINES

Hydration and fibrillation commence as soon as the pulping operation starts. Cutting also may be accomplished at any time during the cycle by simply increasing the bed plate pressure against the knives.

Control Panel Is Available

The BEATAPULPER can be obtained with a control panel. The panel contains a recording pressure gauge and recording ammeter, together with a convenient means for adjusting the bedplate pressure against the knives. The bedplate also may be disengaged from the knives.

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Ketchikan

The Ketchikan Pulp Co. has acquired a plant site of 58 acres and plans to build a pulp mill with a daily capacity of 300 tons at Ward Cove, 7 miles from Ketchikan, in Southeast Alaska. The mill will be constructed so that its capacity can be increased to 525 tons per day. Ketchikan is a community of about 6000 people, where housing, schools, churches, stores, and theaters are similar to those in small cities in the United States. Additional housing will be available without financing by the Ketchikan Pulp Co. The city of Ketchikan is modern and progressive and has an $8,000,000 improvement program for streets, sewers, water mains, and other developments.

The climate at Ketchikan is moderate. Published data show an average temperature of 32.6°F. in January and 57.5°F. in July. Rainfall is heavy, with annual precipitation of about 150 inches.

Timber in the Tongass National Forest, according to forestry experts, consists of 67% hemlock, 24% spruce, and 9% red and yellow cedar. The 50-year contract for the sale of the timber to the Ketchikan Pulp Co. by the United States Dept. of Agriculture is the largest such transaction ever consummated. The timber covered by the contract is on a tract of 364,000 acres, and the contract provides for the ultimate delivery of 1,500,000,000 cubic feet of pulpwood. This supply is adequate to support a mill with a daily capacity of 525 tons for the period of the contract.

Badger

Hauling of sulphite liquor from Badger Paper Mills to reduce stream pollution was resumed recently. Mill executives plan to continue last Summer's roadbinder program along with an experimental ponding program that has been undergoing tests all Winter.

Last Fall, with the approval and close supervision of state pollution authorities, the Badger mill purchased a stainless steel truck and began hauling spent liquor and dumping it in an isolated pond two miles distant. This went on all Winter, and more than 5,000,000 gal. were thus diverted from polluting the Peshtigo River. Meanwhile state pollution experts have been checking all watercourses in the vicinity and as yet have found no trace of leakage. About a month ago local road authorities urged suspending the program lest the heavy liquor trucks do major damage to wet roads left vulnerable by the Spring thaw. This official ban has just now been lifted, and the hauling truck has gone back to work.

Badger has one representative making calls on town and county highway commissioners to discuss with them how to improve their unpaved roads at low cost by using Badger's sulphite roadbinder for the bare expense of hauling and spreading. This program had its start in 1951, and is expected to keep at least one spreader truck busy until frost time.

Hollingsworth & Vose

The Hollingsworth & Vose Co., East Walpole, Mass., manufacturer of rope jute and special wood paper, has in operation a number of horizontal rotary steam cookers, measuring 7 or 8 feet diameter by 24 feet long, for cooking the raw materials—old rags, fibers of various sorts, old rope, scrap paper, etc.

These materials are charged into the large drum boiler, along with water and chemicals, whereupon the mass is cooked under steam pressure for a period of 4 to 6 hours while drum is being revolved at 1 r.p.m.

All of these cookers were originally, and until 1949–50, driven from an overhead line shaft through clutches and flat-belt take-offs to a pair of spur gears constituting the final drive to each drum.

Cookers 5, 6, 7, 8 are now operated by individual Link-Belt Electrofluid drives, connected to spur gear sets through flexible coupling, WB-80 enclosed worm gear, and encased RC-120 precision steel roller chain. No gear sets were replaced.

The Electrofluid drive and enclosed worm gear reduction, which are direct connected by flexible coupling, are mounted on a welded steel base plate to assure accurate shaft alignment at all times.

A high inertia load must be overcome in starting up the loaded drum, and there is the added load resulting from shifting of stock in drum while it is revolved.

The Electrofluid drives, which are push button controlled, have proved to be ideal for the purpose, because the automatic action of their fluid coupling assures smooth, easy starting of loaded drum—and continued smooth running—at minimum horsepower.

One drive uses a 5-hp. motor; the other three are $7^1/_2$-hp.

Another feature that is particularly gratifying to the user is the elimination of high maintenance cost of the old belt drives from line-shaft.

Cooking of the raw materials is the first step in reducing them to pulp of proper quality and consistency. Then come the beaters, followed by other pulp refining units.

"Blotter" Analysis for Plastics

James H. Freeman, a scientist at the Westinghouse Electric Corp.'s Research Laboratories, has found a new analytical method of determining the chemical composition of bakelite-type plastics.

The "Blotter" technique—more precisely called paper chromatography—was first used by chemists 100 years ago. In the last decade it was revived and used in the study of proteins. Only within the last year, however, has the method been applied to the study of phenolic resins and plastics.

Everyday items made from these bakelite-type plastics include: radio and television cabinets, electric light switches, telephones, electric fan blades, the handles on electric irons, and bearings for many machines. Dr. Freeman's new analytical tool will have particular application in the development of insulating resins and varnishes for Westinghouse equipment.

Here is how the paper chromatography technic is applied: a strip of white blotterlike paper is suspended in a large glass jar about 2 feet high. Pinpoint samples of known and unknown ingredients of a phenolic plastic are placed at intervals along the top of the paper. The top of the strip is held in a glass trough filled with a solvent capable of dissolving the samples. More of the solvent is kept in a small dish in the bottom of the jar to keep the air inside saturated.

In much the same way that a blotter corner draws ink from a spilled drop, the solvent begins to "run" down the paper and carries the ingredient samples with it. After 15 or 16 hours, the solvent "front," or its leading edge, has nearly reached the bottom of the paper which still appears white. However, when an "indicator" chemical is "painted" on the paper, different colored spots appear. Their position on the paper enables the scientist to identify them. The color of the spots serves as an additional check.

Dr. Freeman said the primary value of this method of analysis when applied to resin chemistry is that it provides a specific and highly sensitive technique by which given substances including some previously unknown ones may be separated and identified.

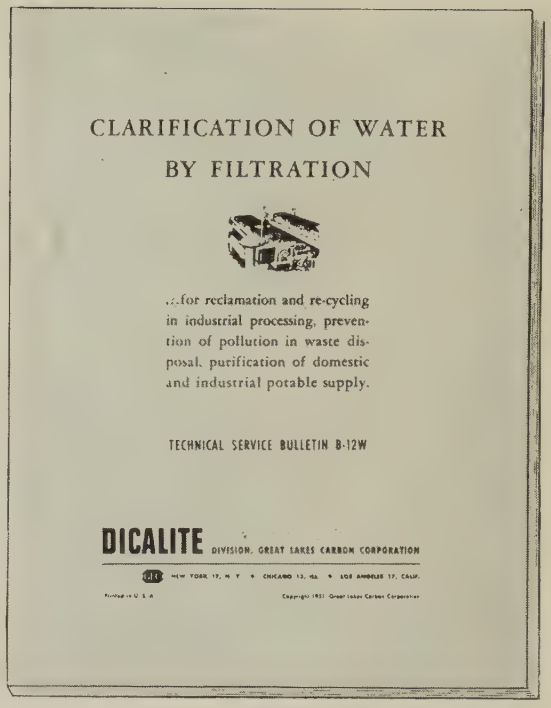
Roadbinder

Unpaved roads that were properly treated last year with sulphite roadbinder came through the Winter with a minimum of frost damage, Walter A. Sherman of Park Falls, Wis., has announced, after completing an inspection of many miles of county and township roads in this area. Sherman made his inspection trip in company with technical men representing Michigan, Minnesota, and Wisconsin sulphite mill members of the Roadbinder Association, which he heads. Also participating were technical representatives of the Sul-

Two New Technical Bulletins for PAPER MILLS

USE OF DICALITE PAPER-AIDS IN THE FURNISH

BULLETIN F-52—Newly revised. Describes Dicalite diatomaceous paper-aids, giving the chemical and physical properties. Methods of adding to the furnish, quantities ordinarily used for various types of paper, and results to be expected are explained in detail. A section is also devoted to white water filtration using Dicalite filteraids.


CLARIFICATION OF WATER
BY FILTRATION
...for reclamation and re-cycling in industrial processing, prevention of pollution in waste disposal, purification of domestic and industrial potable supply.
TECHNICAL SERVICE BULLETIN B-12W
DICALITE DIVISION, GREAT LAKES CARBON CORPORATION

DIATOMACEOUS FILTERAIDS FOR WATER FILTRATION

BULLETIN B-12W contains a section somewhat more complete than Bulletin F-52 on white water filtration, in addition to data on filtering other waters. It covers the general subject of filtration for reclamation and re-cycling water in industrial processing, prevention of pollution in waste disposal, and purification of domestic and industrial potable water supply.

DICALITE DIVISION, GREAT LAKES CARBON CORPORATION

GLC

NEW YORK 17 · CHICAGO 1 · LOS ANGELES 17

Write to: 612 S. Flower St., Los Angeles 17, Calif.

phite Pulp Manufacturers' Research League and research men from the University of Wisconsin Engineering Experiment Station who have been working on this general problem under a grant from the League.

All roads checked in the Appleton area showed some frost damage, according to Sherman, but damage on those treated in last year's roadbinder program was less severe and involved smaller fractions of the roads' total surface. One test stretch which used four different types of sulphite liquor last Summer was good all the way. Some of the roadbinder-treated surfaces came through in better shape than many black-top roads.

The members of the inspection party reported that the same condition prevails generally in all areas where extensive roadbinder programs were carried on last year by sulphite mills to reduce stream pollution. Winter damage results were equally favorable wherever the roads were treated by technically proved procedures.

Last year in Wisconsin alone more than 23,000,000 gal. of spent sulphite liquor were used in the roadbinder program, keeping this liquor from damaging fish in streams. Now roadbinder programs are starting up once more, and still larger quantities will be used in 1952. The total will be limited only by the amounts that county and township highway officials are willing to accept from the mills for the bare cost of hauling and spreading. All Wisconsin sulphite mills can provide information on roadbinder, and most of them still have supplies of this material that have not yet been spoken for.

Waste Treatment at Tyrone

The waste treatment system at the Tyrone mill of the West Virginia Pulp & Paper Co. is preventing the discharge to the stream of about 115 tons daily of solid materials which formerly went to the waterway and caused gross pollution of the water and heavy clogging of the stream bed. The daily volume of wastes at the mill is approximately 6 million gallons, a small portion of which comes from the making of pulp.

All mill wastes are discharged to a central sump and from there are discharged to the treatment system which includes concrete basins with a capacity of 519,000 gal. in which the solids settle to the bottom and are scraped to a sump. From that point the sludge, comprising the solids, is removed by a conveyor to a reservoir and from there is trucked to a lagoon.

In draying the sludge to the lagoon it was necessary to go through the borough of Tyrone. Sludge drained from the trucks and brought complaints which led to a dewatering experiment. A basin, the bottom of which was lined with cinders, was constructed. The sludge was pumped into it and in 24 hours it had dried sufficiently to be handled by mechanical loaders. The experiment was continued over a sufficient period to get results under varying conditions and proved successful. A series of basins are now being built to handle all the sludge from the wastes. It is said to be the first case in this state of dewatering paper mill wastes by this method.

The Tyrone mill is located on South Bald Eagle Creek, less than a mile above where it enters the Little Juniata River.

Similar improvement through treatment of wastes is being accomplished at the Williamsburg mill of the paper company which is located along the Frankstown Branch of the Juniata River. The mill is of smaller capacity than the Tyrone mill and more than 75 tons daily of solids are being kept from going to the waterway.

Maine Birch Scourge

A scourge that has killed an estimated 67% of Maine birch trees during the past 12 years has passed its peak, the Maine Forest Service believes.

Damage is attributed to the bronze birch borer, the long drought which weakened trees, delayed cutting of forestlands, and other factors not yet determined.

The worst damage is in old, dominant, mature, and overmature stands of low vigor. Young stands are reported to have suffered little damage.

Chemical Debarking Tool

A special tool for stripping bark from standing trees and another instrument for applying poison to the resulting tree girdle have been developed by the Northeast Pulpwood Research Center. The organization hopes to have the equipment ready for use during the coming sap season.

The girdling tool is based on a design principle proposed by Don McLeod of the Eastern Pulp Wood Co. It does not cut into or otherwise damage the sapwood.

Preliminary tests last year showed that a man using the device can girdle trees three times as fast as with an axe. The device's application is limited to bark not over $^5/_8$ inch in thickness. However, this permits its use on nearly all spruce and fir trees and on most second growth hardwoods up to about $1^1/_2$ feet in diameter.

A back pack tank and pressure feeding brush combination has been devised for applying the chemical. This permits better paint utilization and eliminates "messiness."

The bark loosens naturally on trees that are chemically treated during the sap season. This eliminates the necessity for mechanical debarking after the trees are felled. Peeled pulpwood then becomes a year-around crop, to be harvested at the landowner's convenience.

Glass Newsprint

According to *Editor and Publisher* (March 29) R. H. Barnard, President of Glass Fibres, Inc., predicts that newsprint will be produced from glass fibers instead of wood pulp within a decade. Experiments are proceeding in the company's plant at Defiance, Ohio.

Career Education

The University of Maine Foundation, Orono, Me., has issued an interesting 16-page booklet "Education for Your Career." It is designed to acquaint secondary school students with opportunities that are open in the pulp and paper and allied fields and the educational program of Maine. The Foundation would like to have this bulletin reach every high school student that may be interested in pulp and paper manufacture as a career.

Finland

In 1951 cellulose production reached postwar record in Finland. Of the total produced (1,385,766 tons), 615,690 tons of sulphite and 417,365 tons of sulphate were sold to domestic and foreign consumers, or 1,033,055 tons in all. Of the quantity sold exports accounted for an aggregate of 979,136 tons.

Deliveries of wet mechanical pulp, available for sale increased to 155,937 tons (dry weight) and of dry mechanical pulp to 50,664 tons, or to a total of 206,601 tons (178,905 tons in 1950). The power shortage due to a dry Summer and Autumn reduced production at export pulp mills. Over 30,000 tons of contractural deliveries had to be canceled. The Autumn of 1951 was the driest on record for the entire period over which statistics on rainfall have been compiled.

Exports of board accounted for 143,000 tons of the total output of 205,000 tons in 1951.

Wallboard production was 63,000 tons of porous and 54,000 tons of hard wallboard. Domestic consumption of the porous quality was 33,500 tons and of hardboard 9400 tons in all.

The largest buyer of Finnish paper was the United States. Second place was held by England and next came Argentina, Denmark, Brazil, Australia, Western Germany, France, Egypt, and India.

Kootenay

A 20 million dollar pulp mill is under way at Nelson, B. C., for Kootenay Forest Products Ltd. Washington State in-

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all applications

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WORCESTER, MASSACHUSETTS
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terests associated with the Glacier Lumber Co. of Nelson are in back of the project. Walter M. Lentold, pioneer Washington lumberman, is President of the new company.

Canada

Total Canadian pulp production during the first quarter of 1952 was 2,284,242 tons, compared with 2,208,141 tons in the same 1951 period. The total amount used in Canada was 1,726,063 tons, while 529,413 tons were exported.

Quartz Paper

Scientists at the Naval Research Laboratory are working on a new type of quartz paper. Conventional papermaking equipment is used. Quartz fibers average about one hundredth the thickness of human hair. The product holds up at temperatures as high as 3000°F. It can be used for electric insulation.

Multiwalls

Last year, the chemical industry used one fifth of all of the multiwall bags sold (2.25 million or ten times as many as in 1934). Food and agricultural products are the principal commodities shipped in multiwalls, chemicals are second, followed by building materials and minerals. Multiwalls sell in the range of 5–30 cents each for 100-lb. bags in lots of 1000.

Naval Stores

Export markets for gum naval stores are dwindling. No satisfactory way of establishing a "market" for the industry to base prices on has been found since the abolition of the Savannah Naval Stores Exchange on anti-trust grounds; and competition from other products such as tall oil and sulphate rosin is growing. Research may open new markets.

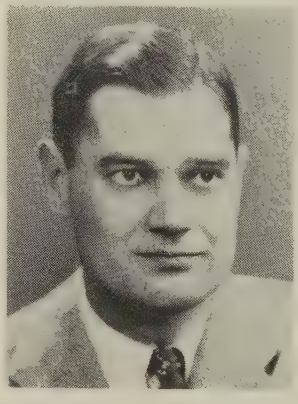
Witco

Witco Chemical Co. has organized an Oil Black Div. which includes the Continental Carbon Co. plant in Sunray, Tex., and the Continental oil black plant in Westlake, La. J. H. Wishnick and R. A. Reinke have been appointed Manager and Superintendent, respectively, of the new Division.

Beloit

At the meeting of the Board of Directors of the Beloit Iron Works, Beloit, Wis., E. H. Neese was elected Chairman of the Board. He was succeeded as President by Harry C. Moore. Other officers elected included: C. E. Maclern, W. S. Wood, Lloyd Hornbostel, J. E. Goodwillie, Vice-Presidents, and E. C. Smith, Secretary.

E. H. Neese,
Beloit Iron Works

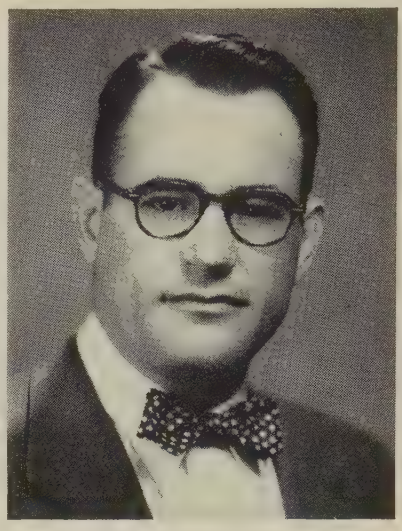


H. C. Moore,
Beloit Iron Works

Beloit Iron Works was founded in 1858. It was reorganized in 1885, and Alonzo Aldrich became President 4 years later. At the death of Mr. Aldrich in 1931, Mr. Neese was elected President. He joined Beloit in 1916 as Vice-President, after serving as an officer of one of the other builders of papermaking machinery. The plant now employs 1800 men and women. Mr. Moore joined the company in 1936.

Lockport Felt

John A. Manley, formerly of du Pont, has become associated with the Lockport Felt Co., Newfane, N. Y., as a field representative covering Delaware, Maryland, Pennsylvania, and New Jersey. This territory was formerly covered by W. W. Campbell, Jr., now Assistant Sales Manager. Mr. Manley will be located at 2730 Eldon Ave., Drexel Hill, Pa.



W. W. Campbell, Jr.,
Lockport Felt Co.

The Lockport Felt Co. is sponsoring a fishing contest, open only to employees of pulp, paper, and paperboard mills. In November, 1952, 45 prizes will be given to successful fishermen, entered in the contest between April and October. The national grand prize is a 10-hp. Johnson outboard motor. There will be 15 prizes of $100 Savings Bonds, 15 of $50 bonds, and 15 of $25 bonds. Rules and application blanks are obtainable either at any paper mill or from Lockport Felt Co., Newfane, N. Y.

Foxboro

Foxboro Co., Foxboro, Mass., has issued two new bulletins. Bulletin 461 contains specifications, controller air-connections, etc., for the M/40 Controllers. These controllers are used in connection with temperature, pressure, flow, pH, conductivity, etc. A new Bulletin 405 describes the Dynalog instruments for recording and controlling roll surface temperatures.

Westinghouse

Westinghouse Electric Corp., Box 2099, Pittsburgh 20, Pa., has issued a 28-page booklet (B-5477) on "Preventive Maintenance," especially for power equipment. A booklet (B-4766) describes complete maintenance service for electrical apparatus. A new catalog (600) describes the air-conditioning and air handling machinery of the Sturtevant Div.

James M. Wallace, formerly Manager of the Switchgear Distribution Apparatus Dept. of Westinghouse, has been named Manager of the Meter Div. at Pittsburgh. He succeeds G. H. Grossnickel who has been appointed Manager of Manufacturing.

General Electric

General Electric Co., Schenectady, N. Y., has issued a new 8-page bulletin (GEA-5781) which is a selection guide for a wide range of electric and electronic controls.

International Nickel

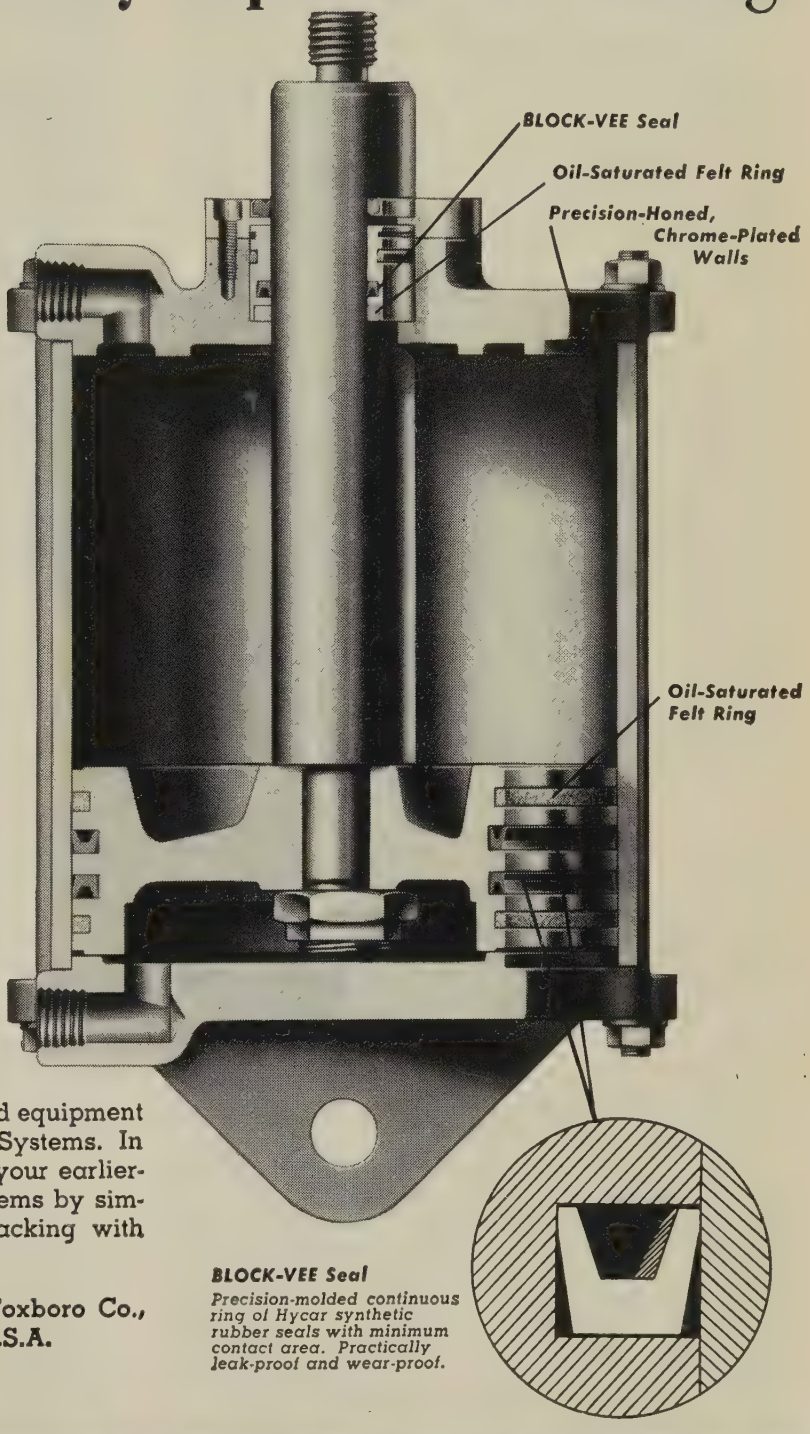
The International Nickel Co., Dept. EZ, New York 5, N. Y., has issued a 44-page illustrated bulletin on "Practical Nickel Plating." It provides the designer and specifying engineer with basic information on electroplating. Thickness and type of nickel deposit for adequate service life in many corrosion-resistant, industrial, and electroforming applications are discussed.

NOW... unique Stabiload cylinder radically improves roll loading!

Ends stickiness and air leakage in pneumatic loading

Designed specifically for Foxboro Pneumatic Loading Systems, the new Foxboro STABILOAD Air Cylinder now makes possible more-accurate and more-uniform moisture extraction . . . safely permits higher nip pressure . . . than ever before could be obtained with loaded rolls.

Through use of the exclusive Block-Vee Piston Seal and precision-honed, chrome-plated cylinder wall, Stabiload Cylinders are so nearly friction-free that even fractional changes in air pressure settings give immediate, corresponding changes in roll nip pressure. You'll get substantial savings in maintenance because the Block-Vee Seal never needs attention or adjustment. And the virtual elimination of air-leakage gives substantial savings in compressed air.



STABILOAD Air Cylinders are standard equipment on all new Foxboro Pneumatic Loading Systems. In addition, you can importantly improve your earlier-model Foxboro Pneumatic Loading Systems by simple replacement of piston, rod and packing with STABILOAD components.

Write for detailed Bulletin 446. **The Foxboro Co., 786 Neponset Ave., Foxboro, Mass., U.S.A.**

BLOCK-VEE Seal
Precision-molded continuous ring of Hycar synthetic rubber seals with minimum contact area. Practically leak-proof and wear-proof.

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PNEUMATIC ROLL-LOADING

FACTORIES IN THE UNITED STATES, CANADA AND ENGLAND

D. J. Murray

F. C. Boyce has been re-elected President of the D. J. Murray Mfg. Co., Wausau, Wis., for the 20th consecutive time. Other officers elected were: M. P. McCullough and D. C. Everest, Vice-Presidents, A. W. Plier, Executive Vice-President and General Manager, G. L. Ruder, Treasurer, W. A. Marquart, Secretary, and C. L. Durkee, Vice-President and Sales Manager.

An addition of 37,000 square feet will be added to the D. J. Murray plant at Wausau. Completion is scheduled for September. Gross sales in 1951 were over 5 million dollars.

The company has announced its new Murco-Collard pneumatic collapsible shafts for winding or unwinding paper without mandrels, chucks, collars, keys, wedges, or other accessories commonly used for these operations. It expands in a true circle by applying air through a valve on the tending side of the journal.

Raybestos-Manhattan

Harold H. Burrows has been appointed Sales Manager of the Industrial Rubber Goods Div., Raybestos-Manhattan, Inc., Passaic, N. J. Charles P. McHugh has been appointed Manager of the Roll Covering and Tank Lining Production Depts., succeeding Mr. Burrows.

Link-Belt

Link-Belt Co., 307 N. Michigan Ave., Chicago 1, Ill., has issued a new 28-page booklet (2475) on Bulk-Flo Conveyors for wood chips, etc.

Butterworth

J. Ebert Butterworth has been elected President of H. W. Butterworth & Sons, Bethayers, Pa., succeeding Harry W. Butterworth, Jr., who became Chairman of the Board.

Graton & Knight

Frank A. Brede has joined Graton & Knight Co., Worcester, Mass., as Chief Engineer, Transmission and Development.

Allis-Chalmers

Allis-Chalmers Mfg. Co., 828 S. 70th St., Milwaukee, Wis., has issued a new bulletin (51B7693) on "Squirrel-Cage Induction Motors."

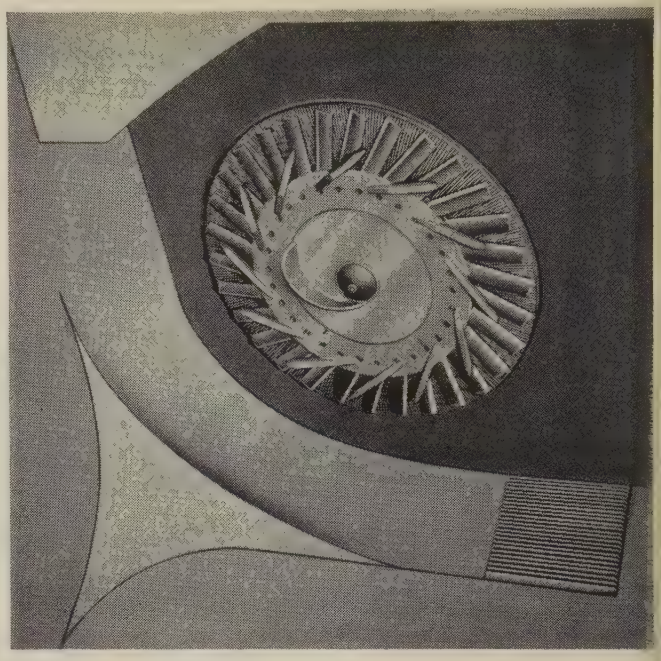
A.-C. now has available 35-mm. sound film strips on centrifugal pumps for showing before interested groups. These include "How and Why of Centrifugal Pumps," "Pump Maintenance," and "Covering All Angles." Requests for showing should be made to the nearest Allis-Chalmers district office.

Staley

A. E. Staley Mfg. Co. has established new sales offices at Cleveland and Philadelphia. L. H. York has been named manager of the Cleveland office with Jack Kraus as assistant manager, and H. J. Reavis will manage the Philadelphia office with Harold Hiser as assistant manager.

Cowles

The Cowles Co., Cayuga, N. Y., has brought out a new unit that pulps, defibers, and refines paper stock all in one operation. It is known as the "Beatapulper." It has been



New Cowles Beatapulper which pulps, defibers, and refines all in one operation

used to treat such furnishes as hard, dry groundwood, West Coast and Swedish kraft, soft pulps, wet-strength trim and broke, resin-coated waste, corrugated kraft box cuttings, deinking ledger and magazine papers.

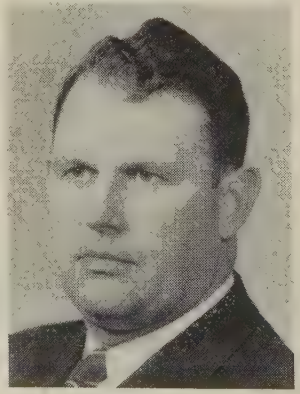
Dow

A. A. Butterworth has been appointed Supervisor of Plastics Sales for the Philadelphia office of the Dow Chemical Co. John B. Rutherford will replace Mr. Butterworth as plastic molding powder salesman for the Philadelphia area.

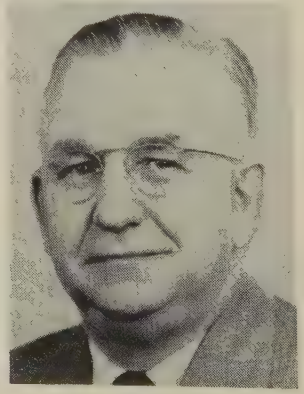
Monsanto

Monsanto Chemical Co., St. Louis 4, Mo., has issued a bulletin on Santicizer 3, a sulphonamide-type plasticizer, especially useful in formulating heat-sealing or heat-sensitive adhesives and lacquer coatings. It contains formulations for nitrocellulose heat-sealing coatings and paper-coating lacquers, polyvinyl acetate adhesives, and zein metallic decora-

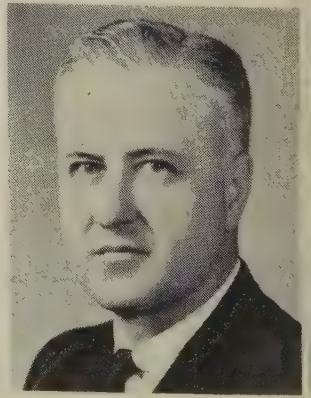
L. H. York,
A. E. Staley Mfg. Co.



J. F. Kraus,
A. E. Staley Mfg. Co.



H. J. Reavis,
A. E. Staley Mfg. Co.



H. R. Hiser,
A. E. Staley Mfg. Co.

A TRADITION OF QUALITY

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SMOOTH SURFACE

DIAMETER ACCURACY

AMPLE SPIDERS

SHRINK FIT -- NO SET SCREWS

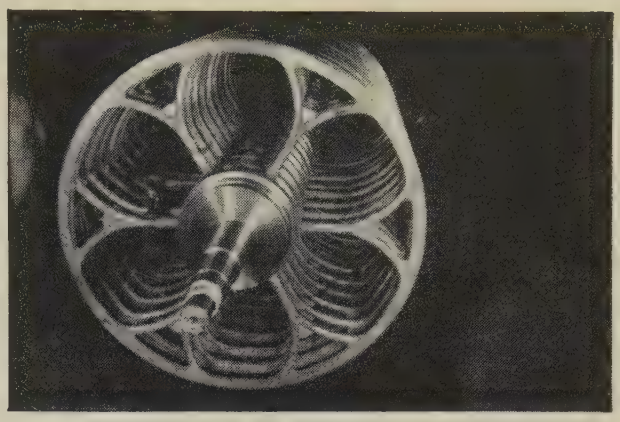
CENTRIFUGALLY CAST SHAFTS

CORROSION RESISTANT

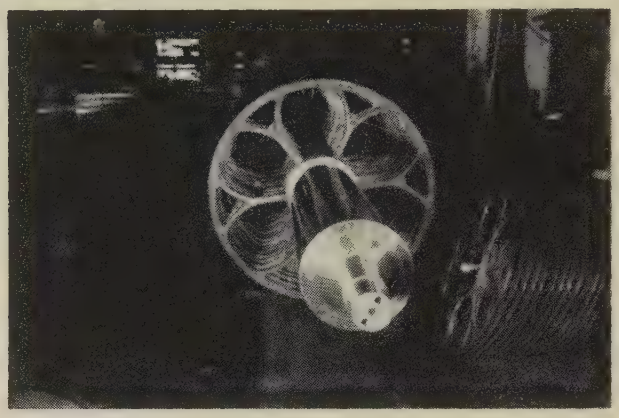
RUGGED CONSTRUCTION

DEPENDABLE WORKMANSHIP

STANDARD and SPECIAL
CONSTRUCTIONS
INCLUDING "SMOOTH-FLOW"
RODS and WINDING WIRE



GOOD DESIGN



GOOD MACHINING

GOOD TOOLS

"WE RECOVER CYLINDERS ACROSS THE COUNTRY"

The Sinclair Company
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UNITED STATES OF AMERICA

THE SINCLAIR COMPANY

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FOURDRINIER AND CYLINDER WIRES, DANDY ROLLS, STANDS AND DRIVES

TOP QUALITY SERVICE TO A TOP QUALITY INDUSTRY

tive paper coatings, back coatings for pressure-sensitive tapes and hot-melts for paper adhesives.

Cyanamid

J. M. McNamee has been appointed Sales Representative for the Industrial Chemicals Div., American Cyanamid Co., in the Georgia and Florida district. He will be located at Atlanta, Ga.

B & W

The Babcock & Wilcox Co. has moved its headquarters from Liberty St. to the Chrysler Building East, 161 E. 42nd St., New York, N. Y., where it will occupy five floors. Two hundred and twenty truckloads were required in making this transfer. The company was located on Liberty St. since 1868.

Black-Clawson (Shartle & Dilts)

Black-Clawson Co., Hamilton, Ohio, has issued a new 12-page bulletin (6-BC) showing the stock preparation, paper forming and paper converting machinery made by B.-C. and its affiliate, Shartle Bros. Machine Co. and the Dilts Machine Works.

A Kohler system of continuous winding and unwinding equipment was recently installed by Dilts in the Carthage, N. Y., mill of the St. Regis Paper Co. It is used in connection with a polyethylene extruder laminator.

Du Pont

W. Sam Carpenter III, who has been Director of the Acetate Div., has been appointed head of the Rayon Manufacturing Div. of du Pont. William L. Scarborough will direct the Acetate Div.

The 150th anniversary of du Pont will be celebrated on July 18 at the site of the first du Pont powder mills on the banks of the Brandywine Creek, a few miles from Wilmington, Del.

Pennsalt

Hubert A. DesMarais is now Sales Manager of the Pennsylvania Salt Mfg. Co. of Washington., 2901 Taylor Way, Tacoma, Wash. Mr. DesMarais was with the General Dyestuff Corp. in San Francisco since 1932.

H. A. DesMarais, Pennsylvania Salt Mfg. Co.

R. T. De Pan, Sandy Hill Iron & Brass Works

Sandy Hill

Raymond T. De Pan, formerly of the Downingtown Mfg. Co., has joined the Technical and Sales Organization of the Sandy Hill Iron & Brass Works, Hudson Falls, N. Y. Mr. De Pan was formerly with the Flintkote Co. at East Rutherford, N. J.

Arabol

Arabol Mfg. Co. has opened its Plant No. 7 at Itasca, Tex. Arabol is the oldest big firm making industrial adhesives.

The new plant of the Arabol Mfg. Co. at Itasca, Tex.

The first plant was established in New York City in 1885. The Itasca plant will be under the supervision of Roger A. Bailey.

Solvay

The Solvay Process Div., Allied Chemical & Dye Corp., recently dedicated its new 10 million dollar soda ash plant at Syracuse, N. Y.

Hooker

Hooker Electrochemical Co. has let a contract for its 10 million dollar chlorine-caustic soda plant to be built at Muskegon, Mich. It is now studying British Columbia markets to determine if it should build there.

Sulphur

U. S. sulphur producers set a new production record in 1951. According to the Bureau of Mines, 5,278,249 long tons of sulphur were produced in 1951. This is 2% more than in 1950.

General Dyestuff

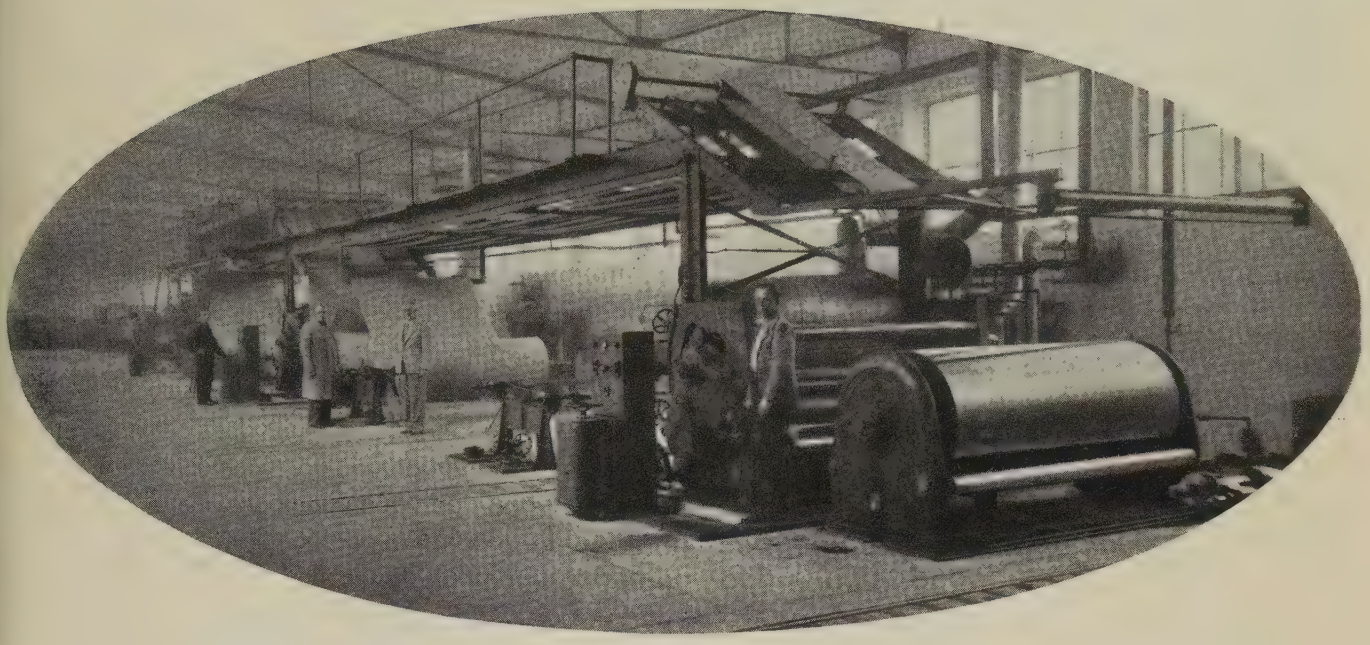
The General Dyestuff Corp., 435 Hudson St., New York 14, N. Y., has issued a new circular AP-24 Igepal CO Extra High Conc. in the Paper Trade. This product is used for felt washing and in the manufacture of dissolving pulps for rayon and cellophane to remove traces of resinous and waxy materials.

Stowe-Woodward

Sales Engineers from all territories again gathered at the home office of Stowe-Woodward, Inc., Newton Upper Falls, Mass., for their annual conference with executives and technical men from the plant. The two-day session on March 26 and 27 was held at Brae Burn Country Club. A program organized and presided over by Frederick L. Phelps, Manager of Roll Sales, covered all fields on rubber roll operating conditions and problems, as well as the latest developments in rubber roll manufacture. Actual mill operating performance reports were of particular interest in bringing up to date the developments in Stowe-Woodward's Sto-Prene press rolls, Microrok press rolls, and Silicone compounded rolls.

Sales Engineers attending were: Oliver P. Arnold, Roger P. Arnold, John D. Dickson, Asa F. Fisk, John H. Glander, Edward S. Greene, William E. Greene, Howard H. Jensenius, Clarence Morganstern, John D. Retallick, Charles M. Scher-

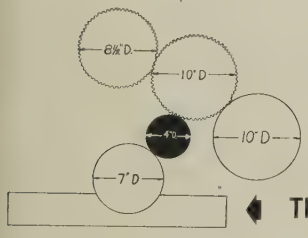
ANOTHER NEW S&S INSTALLATION



The new plant of Dusseldorfer Verpackungindustrie, Dusseldorf, Germany is S & S equipped. Customer writes of his pleasure in our quick on-time delivery and the splendid performance of the Combiner.

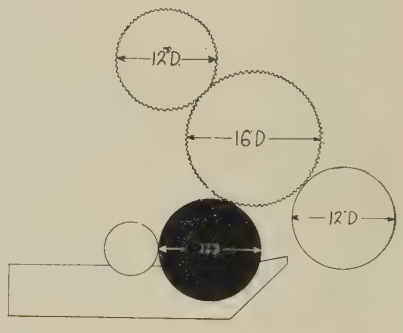
At home or abroad, you can depend on S & S equipment.

A 12″ dia. glue applicator roll instead of a mere 4″ dia. roll eliminates deflection and prevents glue splashing. A 16″ dia. corrugating roll offers greater heat transfer, more moulding surface and less deflection.



THE OTHER WAY

THE S & S WAY



S&S CORRUGATED PAPER MACHINERY CO., Inc.

160 NORTH 4th STREET — BROOKLYN 11, N. Y.

S&S

Founded 1917

merhorn, Roy Tewksbury, Fletcher P. Thornton, Jr., Bradford West.

The following plant personnel were in attendance: Theodore T. Ericksberg, Roll Sales Dept.; Ralph M. Leighton,

Representatives of Stowe-Woodward, Inc., front row, left to right: Howard H. Jensenius, Asa F. Fisk, John D. Retallick, Roy Tewksbury, John H. Glander, William E. Greene. Back row, left to right: Fletcher P. Thornton, Jr., Clarence Morganstern, Bradford West, Charles M. Schermerhorn and John D. Dickson

Chief Chemist; Joseph Mangion, Assistant Chief Chemist; Thomas F. Kenney, Plant Superintendent; Richard E. Gregoire, Foreman, Adams Plant; Arthur Walker, Foreman, Ward Plant; E. W. Peterson, President; Clyde W. Gray, Executive Vice-President; Carroll W. Walters, Assistant to the President.

Dicalite

The new diatomite plant of the Great Lakes Carbon Corp. at Lompoc, Calif., which started shakedown runs April 4, began actual production April 15, 1952, with shipment of the first carload of Dicalite products. Operating adjustments will continue for several weeks, but the new plant is expected to reach near full production by the first week in May.

The new plant is the largest complete unit for processing diatomite built in the last 22 years. With the addition of its full output, capacity for production of calcined and processed filteraids and fillers by the Dicalite Div. will be increased approximately 80%. When the production capacity of the Lompoc unit is added to that of its three other plants in operation, the Dicalite Div.'s total production capacity will be raised to approximately two thirds of the largest annual tonnage of diatomite materials ever produced in the United States.

Following the trend in today's industrial construction, the new Dicalite plant is of the "outdoor" type. The only operation in an enclosed building is the final bagging of the finished products. In many respects the general design and construction is years in advance of other similar units. Some of the equipment was virtually "tailor-made" for the job. The automatic centralized control system for each step in processing is a marvel of electronic engineering. Material handling, from the minute the crude diatomite arrives from the quarries to the time of shipping the finished products, is highly mechanized.

The Dicalite Co., forerunner of the Dicalite Div. of Great Lakes Carbon Corp., was organized in 1929. A deposit of diatomaceous earth was leased in the Palos Verdes Hills, be-

Odor-Treated Goods Are Favored By Customers, Merchants Report

Sindar Aromatics Prove Real Selling Feature in Gummed Paper, Paperboard, Wrapping, Kraft, Parchment and Other Papers

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tween Redondo and Torrance, near Walteria and about 25 miles from Los Angeles.

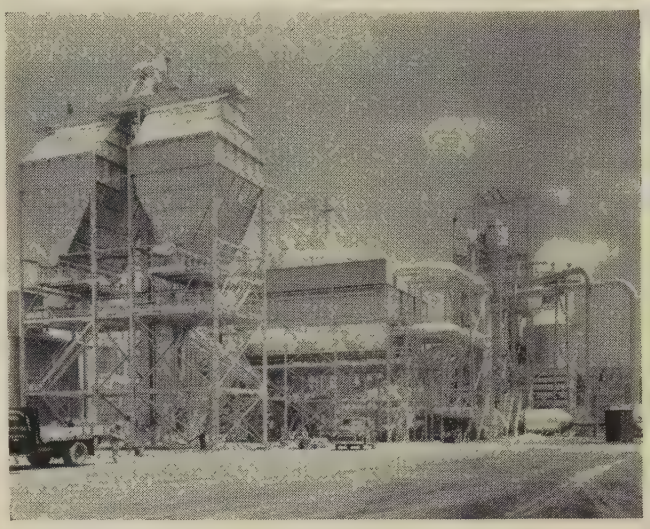
Construction of a plant was started late in 1929 and completed in time to ship the first carload of material on April 1, 1930. From the start the officials of the new company felt that aggressive research in respect to both improvement of their products and finding new applications for them held the best chance for success. That policy still holds.

Despite the fact that the time was not the most auspicious for the beginning of a new business (start of the depression) the new company grew. It grew slowly, but it grew and prospered to the extent that in April, 1936, the deposit and plant of The Oromite Co. near Terrebonne, Ore., was added to its holdings. This plant had been operating for several years with not too much success, although the crude diatomaceous earth was of exceptional quality for making diatomite fillers and filteraids.

A serious setback occurred in May, 1939, when this Oromite plant was almost completely destroyed by fire. The rotary kiln was about all that was salvaged. The plant was rebuilt with improved equipment, newer processing methods were adopted, and operation was resumed in the middle of 1940.

By this time the demand for Dicalite products had increased to considerable proportions, particularly because World War II was having its effect. During the next few years many thousands of tons of Dicalite filteraids, fillers, and insulating materials went into war use, either employed directly by the armed forces or used for production of war materials. After the end of the war, of course, manufacturers of foods, chemicals, and light and heavy durable goods had a tremendous backlog of business, and plants and factories of the nation worked night and day, to catch up with home consumer orders. All this caused the demand for Dicalite materials to keep up the growth started by the war for several more years.

In November, 1944, The Dicalite Co. was purchased by Great Lakes Carbon Corp., and was eventually designated as the Dicalite Div. However, The Dicalite Co. is still in operation as a special sales agency for distribution of Dicalite products in selected areas.



A view of the new diatomite plant of the Dicalite Div., Great Lakes Carbon Corp., Lompoc, Calif.

At the same time Dicalite was purchased Great Lakes Carbon Corp. also bought a diatomite deposit and plant about 60 miles east of Bishop, Calif., near Basalt, Nev. This property covers a vast area and produces special types of materials of high quality.

For superior quality and uniform performance...

STARCHES

OK BRAND STARCHES for tub and beater sizing are of highest quality, uniformly maintained.

AT YOUR SERVICE! The Hubinger technical staff and laboratories are widely recognized for their thorough and practical knowledge of the use of starch in making paper. Their experience assures you of the *best* product, *tailor-made* to fit *your specific needs*. Consult us on any production problem —at no obligation, of course.

THE HUBINGER COMPANY
KEOKUK, IOWA • • • EST. 1881

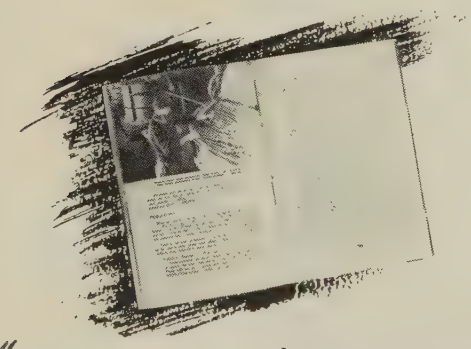
8 Easy to Get Improvements in Mill Operations!

Here are eight improvements involving better quality stock . . . lower operating costs . . . better quality of paper . . . and better storing qualities that can be obtained by the one procedure of adding Magnus Beatex to the beater:

- Freer Stock
- Better Formation
- Really Effective Dispersion of Wax, Ink, etc., from Furnish
- Improved Press Roll Efficiency
- Reduced Beating Time
- Less Water to be Evaporated on Drying Rolls
- Less Slime
- Improved Absorbency where Required

PLUS... ONE MORE!

Added to the white water, Magnus Beatex eliminates harmful aging action on many absorbent stocks.



"Look it up in the HANDBOOK!"

Pages 15 and 16 of the Magnus Paper Mill Handbook are illustrated above. Pages 15 to 18 discuss the theory and practice of Magnus Beatex in paper mill work. If you cannot find your file copy—write us for a fresh issue!

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Magnus
CLEANERS • EQUIPMENT • METHODS

The diatomite deposit near Lompoc, Calif., which will furnish the crude material for operation of the new plant at Lompoc, was leased in May, 1942. Here, as well as in other deposits in California, Nevada, and Washington, the Dicalite Div. has vast reserves of high quality crude diatomite. During World War II the Lompoc quarry was operated to supply additional crude for the plant at Walteria, Calif. From time to time since then crude has been trucked to the Walteria plant for processing.

The Dicalite Div. supplies a considerable foreign market in addition to the United States. Export sales are handled through agents and distributors in virtually all foreign countries. Sales and operating headquarters is in Los Angeles, with New York and Chicago the other important sales centers. Additional sales and technical service offices are maintained in such principal cities as San Francisco, St. Louis, New Orleans, Cleveland, Cincinnati, etc.

The Dicalite Div. is one of six operated by Great Lakes Carbon Corp. Others are the Carbon Div., Electrode Div., Oil and Gas Div., Perlite Div., and the Metallurgical Coke Div.

American Polymer

To meet the demands of the paper industry for a polyvinyl acetate copolymer solution which deposits films with *non-blocking* characteristics, the American Polymer Corp. of Peabody, Mass., has developed Polyco 468. This new product deposits films which are tough, glossy, scuff resistant, water resistant, grease resistant, heat sealable, and possess non-blocking properties. Pressure tests of one pound per square inch at 120°F. and at a relative humidity of 78% show no evidence of face-to-face blocking. Polyco 468 has many uses such as paper coatings, adhesives, inks, lacquers and protective coatings, saturants, and sizings. It can be reduced to a solids content of 45% with ethyl alcohol without causing precipitation of the copolymer. It is soluble in all proportions with ethyl acetate and acetone.

It does not require fusion to achieve good adhesion, gloss, and any of its other properties. However, higher temperature heating for one or two minutes improves adhesion on less porous surfaces. It can also be modified. It can be copolymerized in other solvents to meet your requirements and specifications. Data sheet P-30 gives details.

Bagley & Sewall

The reorganization of Bagley & Sewall's Slitter and Rewinder Div., involving thorough and complete coordination of engineering, manufacturing, service, and sales has been announced by W. A. Zonner, executive vice-president. By closing the New York office and concentrating all operations and functions under one roof at the enlarged and modernized plant and executive headquarters in Watertown, N. Y., the company will be in a better position to service its customers and to avoid delays in answering inquiries.

Bagley & Sewall has been manufacturing slitters and rewinders for several decades and in the last few years a number of new models were added to the company's long-established line. These new models embody many unique and important features, insuring greater speed, accuracy, and economy of operation. According to Mr. Zonner, Bagley & Sewall will continue the manufacture of all established models and he stated that recently developed improvements have resulted in many added advantages to the users of B & S slitters and rewinders. He also pointed out that the company's extensive spare parts inventory will make it possible to render fast and efficient service to customers.

The resignation of Thomas Carter and of Joseph Scheuermann who headed the New York Sales Office, will in no way affect Bagley & Sewall's policies in the development, manufacture, and sales of slitters and rewinders, according to the announcement.

OBITUARIES

C. Laurence Warwick

C. Laurence Warwick, Executive Secretary of the American Society for Testing Materials since 1919, died on April 23 after presiding at a dinner honoring the retiring Treasurer of the Society.

Mr. Warwick was born on July 29, 1889, and graduated from the University of Pennsylvania in 1909 as a civil engineer. While he was a professor at the University, he served as Asst. Secretary of the Society with Edgar Marburg, the Society's founder Secretary. In 1919, at the death of Dr. Marburg, he was appointed Secretary-Treasurer and became Executive Secretary in 1946. During World War II he served as head of the Specifications Branch, Conservation Division, War Production Board. This work resulted in the savings of critical and strategic materials through the issuance of emergency standards and in other ways. He made many contributions in the field of standardization and research in materials.

Karl Erik Sundqvist

Karl Erik Sundqvist, Treasurer and Manager of the Machinery Department of Elof Hansson, Inc., and Industria, Inc., New York, N. Y., died May 6, 1952.

Mr. Sundqvist was born in Vasteras, Sweden, on Jan. 17, 1919, and graduated from Gothenburg Commercial College in 1937. He joined Elof Hansson in Gothenburg in 1937 as Assistant Manager and became Treasurer of Elof Hansson, Inc., in New York City in 1941.

Hans Lagerloef

Hans Lagerloef, 72, died in Weehawken, N. J., on May 11.

Mr. Lagerloef, President of the Lagerloef Trading Co., New York, N. Y., was born in Sweden and came to the United States 49 years ago and entered into foreign trade. He founded the Lagerloef Trading Co. which, for many years, imported most of the Finnish pulp into this country.

He attained world renown as a stamp and coin collector. He gave away several hundred stamp volumes but still owned about 900 volumes at the time of his death. Through his gifts, Sweden was able to build one of the best postal museums in the world.

He leaves his wife, Mrs. Clara Leuz Lagerloef, and two children, Mrs. M. L. Fernstrom and Eric G. Lagerloef.

LETTERS TO THE EDITOR

Cylinder Machines—Some Problems of Design and Operation

To the Editor of *Tappi:*

Referring to your article in the March, 1952, issue of *Tappi* in connection with the above (pages 132A to 136A), you will probably be interested to know that Messrs. Millspaugh Ltd.

They are probably all tempting to you, and they all have one thing in common — they all have been wrapped by *heat seal methods.*

The economies and advantages of heat seal methods are well known. ARCCO offers paper, film and foil converters, a commercially proven line of specialty heat seal coatings and adhesives. They are available in emulsion, solution, and hot melt types and can generally be applied with your present equipment.

They can be engineered to possess various characteristics to suit your particular requirements. An ARCCO engineer will be happy to work with you. Write for data sheets.

ARCCO 1044-29A — Universal Heat Seal Coatings for Glassine, Paper, Aluminum Foil and Cellulose Acetate. Data Sheet C-66.

ARCCO 1044-31 — Heat Seal Coating for Candy Bar Wraps. Data Sheet C-66.

ARCCO 716-6 — Heat Seal Spot Coating for Waxed Glassine. Data Sheet C-66.

FOILAC 1261-12C — (Clear) Solution Coatings for Metal Foils. Data Sheet C-61-R.

ARCCO 1044-27A — **ARCCO 1044-27B** — Heat Seal Greaseproof Resin Emulsion Coatings. Data Sheet A-43.

ARWAX 717-46B — Hot Melt — paraffin wax additive for improved heat seal and improved water-vapor resistance. Data Sheet C-71.

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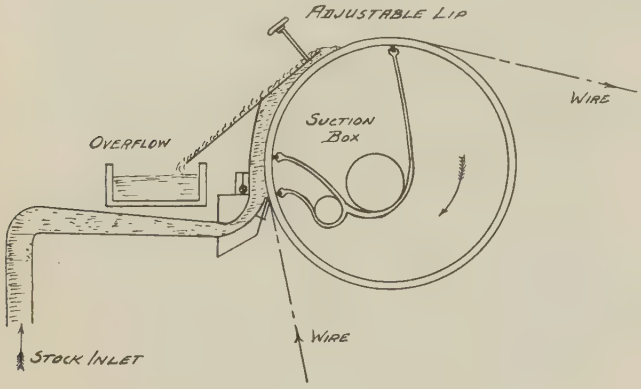
have for some years been engaged in the development of vacuum forming machines.

The illustration in Fig. 10 of your article includes some of the basic principles of our design which is shown diagrammatically on the enclosed sketch No. 21.4.52/HH. Our idea



is already being tried out by some of our papermakers in England but is still treated with a certain amount of reserve due to the natural reluctance to accept new principles. We feel confident that our innovation will ultimately be accepted by the papermakers, due to its simplicity and possibilities of sheet formation at much higher speeds than are at present available with modern methods.

Our idea is covered by British pat. 627,520 and also by patents in force in other continental countries.

H. HOLDEN
Technical Assistant to Managing Director
Millspaugh Ltd., Sheffield, England

Technical Associations

To the Editor of *Tappi:*

I wish to call your attention to three small errors on page 82 A of the May, 1952, issue, under "Technical Associations."

The Secretary of the British Technical Section is named Bolam not Bolan.

The title of Douglas Jones of the Canadian Technical Section is Executive Secretary, and the membership, I am informed, is now 1475 not 1370 which was the membership a year ago.

A. A. SCOTT
Pulp and Paper Research Institute of Canada
Montreal, Que.

EMPLOYMENT SERVICE

POSITIONS OPEN

P208-52. Senior Engineer. Pacific Northwest. Graduate engineer, preferably mechanical. At least five years experience in plant design and operation. Must be competent to appraise equipment requirements and to be able to make complete reports to management for major capital proposals.

P209-52. Manufacturer of Bread Wrapper desires coating chemist familiar with wax-resin formulations applicable to paper for food wrappings. Middle West.

P210-52. Assistant Chief Engineer. Large and progressive company manufacturing pulp and paper products offers excellent opportunity. Company located in Ontario, Canada. Work includes development, design, construction, and maintenance on multiple plant basis, requiring extensive experience. Salary in line with responsibility. Reply in confidence, giving full details.

P211-52. Quality Control Supervisor. Opportunity for security and advancement with well-established and growing organization for competent person with experience in paper converting and printing. Laboratory work and ink formulation experience helpful though chief demand is for application on the production line. Prefer graduate chemist. Write giving information concerning work experience, education, and relevant personal data. Replies confidential.

POSITIONS WANTED

E173-52. Papermaker. 15 years technical and practical experience in fine paper; superintendent of fourdrinier kraft, sulphite and groundwood operation. Can plan and supervise installation of papermaking equipment. Desires position in management, production or sales.

E174-52. Production superintendent or mill manager. 39, married. Experienced in groundwood, sulphite, newsprint, bleaching, and kraft as superintendent. Excellent record in increasing production with existing equipment and lowering costs.

E175-52. Chemical Engineer. More than three years' experience in lightweight papers and laminated plastics. Desires position in development or technical service in either of these fields or in an allied industry. Prefer location in Wisconsin or Northern Illinois.

MISCELLANEOUS

AA-2-52. Commercial testing laboratory interested in purchasing used paper testing equipment.

WANTED: RESEARCH CHEMIST

Immediate opening in research and development department of specialty paper manufacturer. Excellent opportunity for young man with initiative and imagination. Experience or background in paper technology desirable but not essential. In first letter give complete resume of experience, age, education, and present salary. Address Technical Director, Hollingsworth & Vose Co., East Walpole, Mass.

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TAPPI DIVISIONS AND COMMITTEES

Reports of Activities

Chemical Methods Committee

One phase of the Chemical Methods Committee work which was emphasized during the February meeting was the examination of all methods under the jurisdiction of the committee to determine their suitability for the analysis of dissolving pulps. Many of the present TAPPI procedures were developed for less highly refined materials and undoubtedly need to be re-examined for their applicability to very highly refined wood pulps and cotton linters.

Several representatives from suppliers and consumers of dissolving pulp were present to emphasize the needs of this part of the pulp industry. During the committee meeting all of the pulp methods under the jurisdiction of the Chemical Methods Committee were examined with the following questions in mind:

1. Is the method in its present form suitable for highly refined or dissolving pulps?
2. Does the method measure any useful property of dissolving pulp? Some standards developed in previous decades have undoubtedly outlived their usefulness or in some cases two or more procedures are measuring the same property.
3. Are new methods needed for the testing of dissolving pulps?

Methods Needing Modification

A. Pentosans

The present procedure for pentosans in pulp T 223 was developed in years past when the pentosans content of pulps was considerably higher than the level now being maintained in dissolving pulps. As a result the importance of determining small quantities of pentosans has not been properly recognized. In a series of papers sponsored by the Chemical Methods Committee two papers were presented on the problem of determining pentosans in highly refined pulps.

In one paper by Smith and Rogers the shortcomings of the present TAPPI Method were carefully explained. The authors presented a sensitive method based upon the ultraviolet absorption of furfural obtained from pentosans by the regular distillation. Using this sensitive procedure it is possible to distinguish between highly refined pulps which differ only slightly in their pentosans content.

Another paper was presented by Davis and O'Brien describing a colorimetric method (aniline and acetic acid) for the determination of traces of pentosans. Highly refined pulps and cotton linters samples containing 0.15 to 1.2% were analyzed for their pentosans content with precision. These two papers were also thoroughly discussed at the meeting of the Chemical Methods Committee and it was generally agreed that for dissolving pulps some modified method is needed.

There were suggestions in both papers for future work which will be necessary before a new standard can be proposed. It is probable that a method sufficiently sensitive for highly refined pulps will also be suitable for less highly refined pulps so that it will not be necessary to propose a new standard but merely to revise the present one making it applicable to all pulps.

B. Viscosity

Viscosity values for paper pulps are ordinarily not of great importance but for dissolving pulps the viscosity is generally recognized as being of extreme importance.

At the annual TAPPI meeting in February, 1951, and at the Boston ACS meeting in April, 1951, A. F. Martin presented suggestions for modifying viscosity-measuring techniques in such a way as to eliminate much of the controversy which has existed heretofore. This information was published in *Tappi*. Letters from about 25 workers interested in cellulose viscosity methods have shown surprisingly unanimous approval of the major ideas given in this paper.

The Chemical Methods Committee is now actively working on a revision of disperse viscosity procedures. A project sponsored by the Chemical Methods Committee is under way at the Paper Institute at Appleton, Wis. The research of this project is broad but yet practical in nature and has as its objection the selection of the best solvent and test conditions for a TAPPI Standard Procedure. ACS and ASTM Committees are working very closely with the TAPPI Subcommittee.

C. Alpha-Cellulose

The alpha-cellulose procedure is one of several alkali solubility tests. Because of the large quantity of data accumulated in the literature on alpha-cellulose tests it seems desirable to preserve this method in approximately its present form. There have, however, been two alpha-cellulose procedures differing slightly in principle. The ACS alpha-cellulose procedure has always specified that the 17½% sodium hydroxide solution should be diluted to 8.3% after the dissolving period and then allowed to stand for another hour at this lower sodium hydroxide concentration. The present TAPPI procedure calls for a dilution to roughly the same value and then to filter immediately. The proposed revision which seems to be acceptable to ACS, TAPPI, and ASTM, would follow the ACS procedure at this point and allow sufficient time at the weaker concentration of alkali for a new equilibrium to be established.

Grinding will be eliminated from the present TAPPI method, the sample size will be fixed at either two or three grams, and the method of moisture analysis will be modified in the proposed revision. The new procedure should be applicable to dissolving pulps as well as less highly refined materials.

D. Permanganate Number

The three methods T 202, T 214, and T 219 are somewhat related and deal with chlorine number, chlorine consumption, and permanganate number. T 214 "Permanganate Number of Pulp" seems to have the widest acceptance. It is also a much more practical and meaningful test and is widely used as a tool for following pulp cooking or pulp refinement. T 214 in its present form needs several slight revisions. These were discussed at the February meeting and a slightly revised procedure will be submitted to the committee in the near future.

Methods of Questionable Importance

It is possible that some of the present TAPPI methods proposed a number of years ago have lost much of their significance, particularly as far as application to highly refined pulps is concerned. Some of the methods which might fall in this class were discussed at the February meeting.

The Chemical Methods Committee and the entire TAPPI organization have a responsibility for recommending that out-

moded methods be discarded. It is difficult to determine which method should be discarded. As long as a test method is finding some application it is questionable whether it should actually be eliminated from the TAPPI Standards. Questionable methods, however, should be properly introduced and the shortcomings of the Standards pointed out. Workers should be encouraged to rely upon other tests in the evaluation of pulps.

A. Copper Number Test

Several chemists who deal largely with the dissolving pulps expressed serious doubt that copper number determinations are any longer of value as far as dissolving pulps are concerned.

B. Lignin Content of Pulp

Although it is highly desirable to have a very low lignin content in dissolving pulps other tests are usually relied upon to determine the purity of a refined pulp. Rather than testing for lignin most workers run a potassium permanganate number which indicates the extent to which lignin has been removed. There was very little interest shown in trying to improve the method T 222 "Lignin in Pulp" to make it accurate for very low lignin content pulps.

C. A Solubility in Various Sodium Hydroxide Solutions

In addition to the alpha-cellulose test referred to above there are several other tests based on the solubility in sodium hydroxide of different strengths. Some companies use a 1% sodium hydroxide solubility, a 2 *N*, a 7.3%, a 10%, a 7.14%, etc. These are not official standards, and the Chemical Methods Committee should probably take the leadership in singling out the significant sodium hydroxide solubility tests. In one organization the solubility in sodium hydroxide of a certain strength has been measured for a number of years but

A. S. O'Brien, Eastman Kodak Co.; Chairman, Chemical Methods Committee

E. M. Jenkins, Johns-Manville Corp.; Chairman, Structural Fibrous Materials Committee

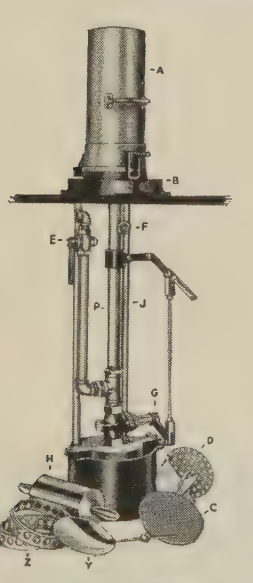
very little significance has ever been attached to the results. One member attending the meeting thought that the only sodium hydroxide solubility test that should receive TAPPI recognization was the alpha-cellulose test. No final decision, however, was reached on this point and the opinion of workers in this field is solicited.

POSSIBLE NEW METHODS

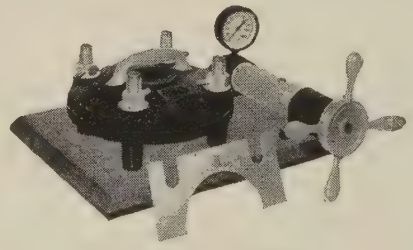
The committee explored the possibility of establishing working groups aimed at proposing new methods which would be of use in the evaluation of dissolving pulps.

A. Chain-Length Distribution

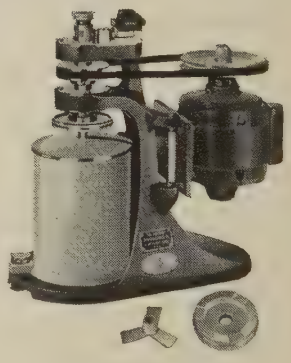
The viscosity project discussed above is aimed at establishing a reliable average value for the degree of polymerization of a cellulose material. There is also considerable interest in



★ SHEET MACHINE
DRYER RINGS
AUXILIARY EQUIPMENT



★ PUMP AND PRESS



★ DISINTEGRATOR

★ TAPPI STANDARD

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the dissolving industry in a chain-length distribution analysis if this could be developed. Most, if not all, of the existing procedures for chain-length distribution are extremely time consuming. The Chemical Methods Committee instructed its chairman to investigate the possibility of a TAPPI-sponsored research project aimed at developing a method for chain-length distribution.

It is possible that the dissolving industry has a need for other methods which the committee could investigate. The chairman of the Chemical Methods Committee would appreciate receiving the reactions of those concerned with the testing of dissolving pulps in regard to the improvement of the existing methods or the development of new methods.

A. S. O'Brien, *Chairman*

Structural Fibrous Materials Committee

Meetings of all subcommittees of the Structural Fibrous Materials Committee were held in New York on February 18. Most of the subcommittees were well represented with the following members:

E. M. Jenkins
J. O. Burton
A. H. Chamberlain
G. H. Chidester
T. C. Duvall
W. D. MacKinnon
J. J. Perot
W. L. Scott
C. K. Textor
E. Frederick
J. F. Campbell
E. J. Jones
W. C. Lewis
M. C. Miller
R. H. Neisel
A. T. Walton
Werner Kaufmann, former Chairman of the Industrial Division
R. W. Kumler, new Chairman of the Industrial Division
Guests: R. E. Green, K. Q. Kellicut, and R. Darland

The subcommittee sessions were devoted to discussions of progress since the last subcommittee meeting and to plans for the coming year. In this way each subcommittee chairman could be prepared with an up-to-date report for the meeting of the committee on the following day.

Mr. Kumler and Mr. Kaufmann, present and past chairmen of the Industrial Division in which the Structural Fibrous Materials Committee functions, were present. Mr. Kumler complimented the subcommittees on outstanding 1951 activity and performance. He discussed the present TAPPI research appropriation service available to worthy projects and also a TAPPI service which will write mill or company managements and encourage personnel participation in committee work and the granting of time and finances to conduct necessary correspondence and to attend meetings.

On February 19 an open meeting of the committee was held in the morning. Three interesting papers were presented, "The Use of Asphalt Emulsions in the Manufacture of Insulating Board Products," by J. J. Perot; "A Preliminary Investigation of the Adaptability of the General Electric Puncture Tester to the Testing of Structural Insulation Board," by A. Van den Akker and a paper on the "Drying of Insulating Board," by H. C. Jessen. Each of these papers was followed by considerable discussion from the floor.

Officers, membership, and subcommittee membership was the first order of business. It was agreed to continue the present officers, chairman, and membership, for the coming year. Chairman Jenkins announced all personnel involved had agreed to continue for another year. He said such a continuous membership was particularly desirable in the case of the subcommittees and their chairmen because of continuing work in a single problem in each subcommittee. The time to change subcommittee personnel is best at the completion of a problem.

Two new members were recommended and accepted for A. T. Walton's Subcommittee No. 6. These recommendations are W. A. Moore of Pioneer Flintkote, suggested by

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6. CORRUGATING STARCHES
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John Campbell and R. D. Ziegler of Washington State College.

Chairman Jenkins asked all subcommittee chairmen not to overlook any additional memberships for their subcommittees that would help the work of the subcommittee and that there be no hesitation in recommending any valuable additional persons for membership.

Two new subcommittees were approved for the coming year. These are:

Consistency Measurements of Insulating Board Pulp Evaluation, Subcommittee No. 9
Test Board vs. Handsheets for Board Pulp Evaluations, Subcommittee No. 10

Membership of the two new subcommittees has been approved as follows:

Subcommittee No. 9:
A. H. Chamberlain, *Chairman*, Bird & Son, East Walpole, Mass.
G. E. Chamberlain, M & O Paper Co., International Falls, Minn.
Mr. Seidl, Forest Products Laboratory, Madison, Wis.
H. M. Sutcliffe, Celotex Corp., Morrero, La.

Subcommittee No. 10:
C. K. Textor, *Chairman*, Bauer Bros. Co., Springfield, Ohio
Lee Eberhardt, Bauer Brothers Co., Springfield, Ohio
F. R. Hyatt, Johns-Manville Corp., Natchez, Miss.

A Steering Subcommittee was appointed during the last year. This executive subcommittee was created to direct more effectively the work of the Structural Fibrous Materials Committee. It is composed of the following members:

E. M. Jenkins, *Chairman*, Johns-Manville Corp., Manville, N. J.
John Campbell, Flintkote Co., Meridian, Miss.
Thure Duvall, Wood Conversion Co., Cloquet, Minn.
E. Frederick, Jr., Celotex Corp., Marrero, La.

The Steering Subcommittee No. 0, held a 1951 Fall Meeting in New Orleans where plans for the present meeting and the 1952 schedules were discussed.

Chairman Jenkins reviewed progress of the SFMC during 1951 noting the issue of TAPPI Suggested Methods T 1001 sm-51 "Forming Structural-Type Boards for Physical Tests of Pulp" and T 1002 sm-51 "Standard Drainage Time of Pulp for Insulating Board." He reported the comments of Ralph Kumler in praise of the work of the SFMC during the past year and expressed his thanks to all the committee and subcommittee members who have made the good progress reported possible.

The Steering Subcommittee raised the question of whether hardboards should not be included within the scope of SFMC activities. Chairman Jenkins reported several hardboard people with whom the subject had been discussed were interested but not sufficiently to undertake the organization of the new group. W. C. Lewis agreed to further explore the possibilities at a west coast hardboard meeting he expected to attend.

In a general discussion that followed on hardboards it was agreed that the SFMC pursue the hardboard subject but should be concerned only with structural boards produced from fibrous pulps. This would exclude strictly resin bonded boards and other products made from unpulped chips, shavings, and the like but would not exclude essentially pulp-made boards where small amounts of binders were added to improve the product.

The Steering Subcommittee also recommended subcommittee chairmen make more liberal use of the committee and TAPPI services. Any tendency for the subcommittees to operate as small completely independent units should be avoided.

Chairman J. O. Burton reported for Subcommittee No. 1, analyses made which resulted in the recommendation that a new subcommittee be established to study pulp consistency

measurements. The recommendation resulted in the appointment of Subcommittee No. 9 with A. H. Chamberlain as Chairman. Subcommittee No. 1 also recommended that rather than establish another finished products testing subcommittee to study dynamic testing that the subject be held until such time as Subcommittee No. 5, Chairman J. F. Campbell, a finished product testing subcommittee, complete their present project of Transverse and Deflection Tests. Mr. Campbell expects Subcommittee No. 5 to finish the present project early in the year.

The report of Subcommittee No. 1 was approved and E. J. Jones started a discussion on the desirability for work being done to further establish the value of the Test Board method for evaluating coarse, insulating board pulps as compared to the present TAPPI handsheet method used for finer pulps. It was agreed such work was desirable and accordingly Subcommittee No. 10 with C. K. Textor as Chairman was appointed. Mr. Textor is in an unusually good position to conduct such work because of a broad experience and the great variety of raw materials that pass through his laboratory.

Chairman Campbell reported for Subcommittee No. 2 and asked for suggestions for 1953. After considerable discussion it was agreed the best program would be one centering on one subject or a group of closely allied subjects. The subject recommended by the committee was "Stock Control." Such subject papers as Stock Drainage Test, Handsheet vs. Test Board Methods, Methods for Test Board Formation, Consistency Control Mechanisms, and like subjects would come under the stock control heading and would work in well with present objectives of the committee.

Chairman R. G. Lacey's report for Subcommittee No. 3 was presented by E. M. Jenkins in Mr. Lacey's absence. He reported good progress had been made, a suggested method prepared and published, and money appropriated by TAPPI for construction of experimental test board equipment. Difficulty was being experienced with priorities in obtaining equipment.

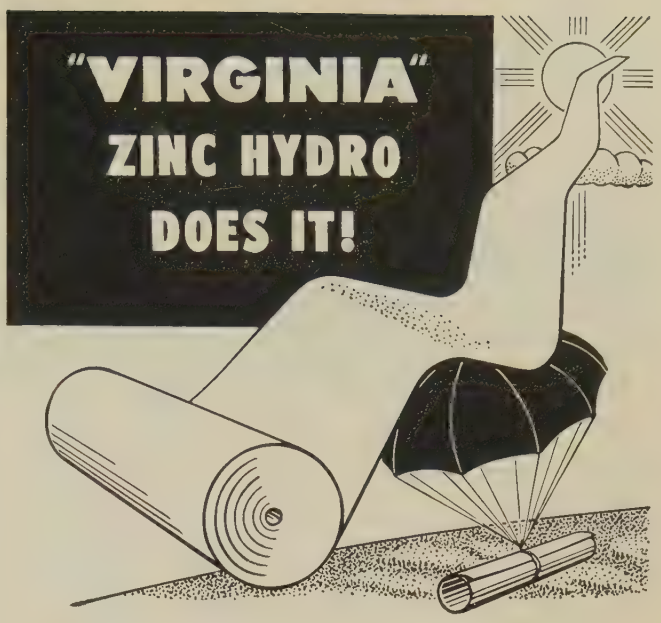
Chairman J. J. Perot reporting for Subcommittee No. 4 also showed excellent progress. He said two Drainage Time Testers have been made and will be delivered soon; that arrangements have been made with C. E. Hrubesky to conduct parallel tests at the Forest Products Laboratory and the Flintkote Laboratory on a selected range of pulp and that the pulps themselves have been collected from various member mills. He also reported a Suggested Method had been prepared and published.

Chairman J. F. Campbell reported for Subcommittee No. 5. Work in Subcommittee No. 5 has progressed so well a final report is expected early this year. The test program at Forest Products Laboratory has been established and the testing should be completed this year, completing the work of Subcommittee No. 5.

Chairman A. T. Walton of Subcommittee No. 6 told of the problems encountered in getting a group organized on the Pacific Coast. He said a review of existing work in the field of the effect of water on insulating board had clarified the objectives of Subcommittee No. 6 and that he had every hope the group would function well in the coming year.

Chairman Thure Duvall summarized the activities of Subcommittee No. 7. Good progress has been made. Existing methods for testing racking and nail holding of insulating board were reviewed and a plan made to adopt a small-scale nail pull-out test to be correlated with a large-scale racking test. The large-scale test may well be the presently developing ASTM test. Money for the test work was appropriated by TAPPI upon request.

Chairman W. L. Scott reported for Subcommittee No. 8 on light reflection that a special meeting of Subcommittee No. 8 was held in 1951 and a plan prepared. A Baumgartner Reflectometer was obtained on loan from General Electric Co. and is being evaluated by Subcommittee No. 8 members. As the General Electric Co. will not allow alterations of the



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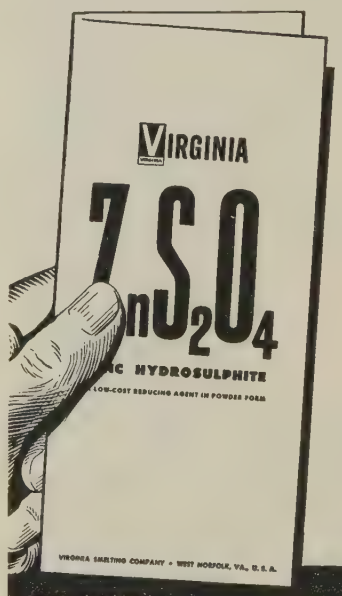

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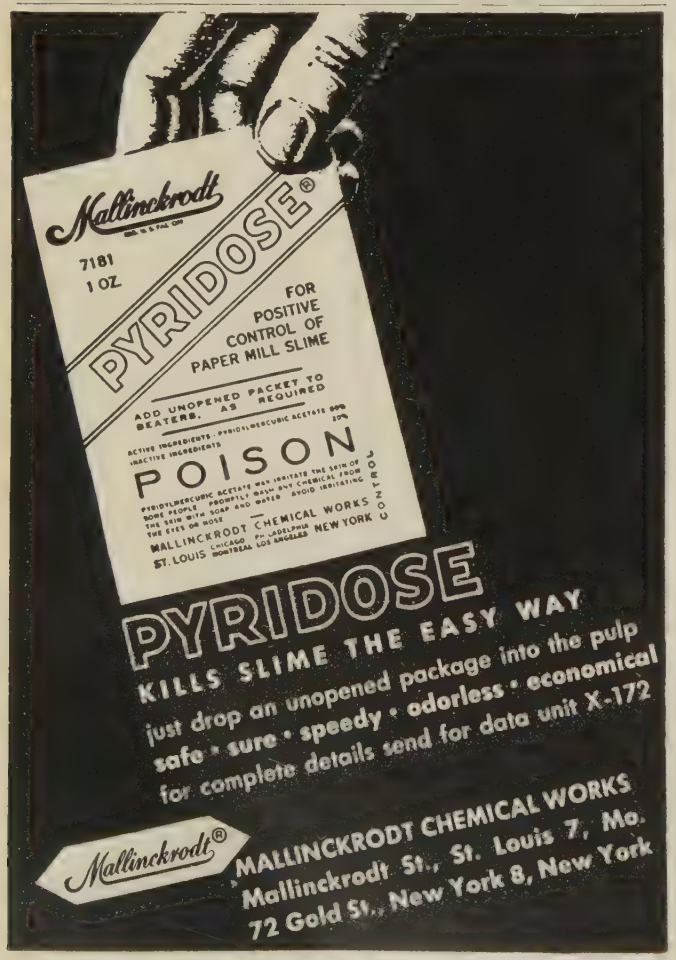
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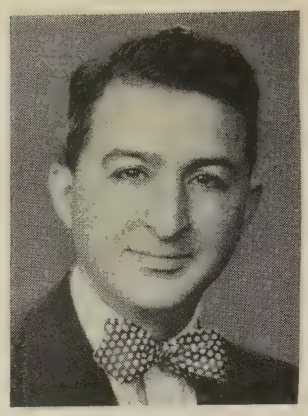
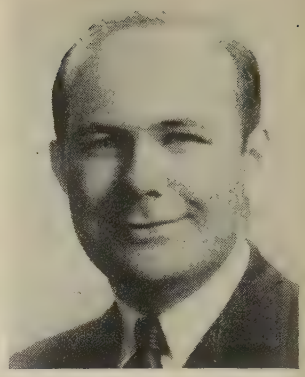


Henry Vranian, Chesapeake Corp. of Va.; retiring chairman, Alkaline Pulping Committee



N. R. Phillips, Champion Paper & Fibre Corp.; Chairman, Papermaking (Fourdinier) Committee

loaned instrument, and as it is already apparent alterations are necessary, Mr. Scott requested that TAPPI appropriate funds to purchase an instrument for the subcommittee.

Contact methods with the Insulation Board Institute were discussed. It was agreed the Production Committee of that organization was interested in the SFMC work and that the Committee Secretary, Emile Frederick, attend the Chicago meeting of the IBI to discuss progress of the TAPPI Committee with the IBI group.

The subject of a Fall meeting for the SFMC was discussed at some length. Chairman Jenkins urged such a meeting be approved because the single annual meeting of past years allows too long a lapse of time for subcommittee and other work to run without guidance of the committee. Also the period of a year is too long a time for the best in aquaintance and exchange of ideas. The committee was generally in favor of a Fall meeting and a temporary subcommittee was appointed to make time and place recommendations, composed of Chairman J. J. Perot, A. H. Chamberlain, and W. L. Scott.

EDWARD M. JENKINS, *Chairman*

Alkaline Pulping Committee

The Alkaline Pulping Committee meeting was called to order on February 18 by the retiring Chairman, Henry Vranian of the Chesapeake Corp. of Va. Election of new officers followed with Robert Fuller appointed Chairman for the year 1952; H. Y. Charbonnier, Program Chairman; and Peter Borlew, Acting Secretary. The Chairman expressed his thanks to the previous Chairman for his excellent work. R. G. Macdonald reported on facilities for the 1952 Fall Alkaline Pulping Meeting.

Mr. Macdonald reported on facilities at the various hotels for the latter part of September for Mobile, Ala. The choice of location was approved but it was suggested that the early part of November be considered as the convention date, shortly after the Chicago Engineering Conference. Mr. Macdonald was authorized to finalize plans with the hotel to assure facilities be available at the proper time. It was also agreed that the program would follow previous patterns of two days of papers and discussion with the third day devoted to mill visits. Preliminary discussions have already been held with some of the mill executives. It was also recommended that the Chamber of Commerce be approached as soon as convenient so that it can assist in convention plans and publicity. The theme of the meeting is to center around "Recovery of Chemicals in the Alkaline Pulping Industry" and will embrace evaporators, recovery furnaces, oxidation towers, sulphur recovery, and may be enlarged to include precipitators as well.

In accordance with the plans drawn up at the 1950 Conference, it was further unanimously approved that the 1953

Fall meeting be devoted to "Alkaline Pulp Washing, Screening and Thickening."

Further, to the scope of the Alkaline Pulping Committee activities a few of the committee members met with the Mechanical Pulping Committee, Mr. Elderkin and Mr. Macdonald, to discuss the proper handling of semichemical papers. This subject is held in abeyance for the moment. Last-minute arrangements were also completed for the joint meeting with the Chemical Engineering Committee during the Convention week. The joint meeting and symposium were to cover all phases of alkaline semichemical pulping.

The subcommittee appointed to evaluate the degree of delignification of high yield pulp tendered an interim report. Peter Borlew, Chairman, was delegated to submit a request to the divisional representative to secure the necessary funds to have the study completed at the Madison, Wis., Laboratory. The undertaking was entitled "To Correlate and Prepare Tables Between the Bathurst Chlorine Number and the Actual Lignin Content of Pulp of Various Degrees of Cooking and from Various Wood Species." This investigation is to get under way as soon as the necessary funds have been appropriated.

It was pointed out that the standard sulphate terminology, TAPPI Standard O 400 p-44, should be reviewed and any necessary revisions or additions submitted. Henry Vranian is to serve as Chairman of the Subcommittee which includes Malcolm Pineo, W. P. Lawrence, and J. McK. Limerick.

All members present stated that they would cooperate fully with the chairmen on any questionnaires that might be sent to the industry.

There being no further business, the meeting was declared adjourned at 5 p.m.

Those present at the Alkaline Pulping Committee meeting were:

Robert R. Fuller, Gulf States Paper Corp.
Henry Vranian, Chesapeake Corp. of Va.
H. Y. Charbonnier, Union Bag & Paper Corp.
Ken Running, Halifax Paper Co.
Burt Helberg, Lion Oil Research Laboratory
A. W. Duskin, Crossett Paper Mills
E. A. Harper, Hudson Pulp & Paper Corp.
Malcolm Pineo, Brunswick Pulp & Paper Co.
W. P. Lawrence, Champion Paper & Fibre Co.
E. W. Keith, Penobscot Chemical Fibre Co.
W. J. Nolan, University of Florida
Wilson F. Brown, University of Florida
David Wetherborn, Southern Paperboard Corp.
Bruce P. Ellen, Southern Paperboard Corp.
Charls F. N. Grobbelaar, South African Pulp & Paper Ind.
R. H. Stevens, National Container Corp.
M. L. Barineat, Jr., Albemarle Paper Mfg. Co.
H. W. Ellerson, Jr., Halifax Paper Co.
K. G. Chesley, Crossett Lumber Co.
K. M. Guest, National Container Corp.
J. Limerick, Bathurst Power & Paper Co.
Peter B. Borlew, Container Corp. of America
Lionel M. Sutherland, Sutherland Refiner Corp.
George R. Tennent, Continental Can Co.
A. P. Yundt, Camp Manufacturing Co.
J. J. Goss, Gaylord Container Corp.
A. G. Durgin, Brompton Pulp & Paper Co.

KENNETH D. RUNNING, *Secretary*

Papermaking (Fourdrinier Committee)

N. R. Phillips outlined the program for the Papermaking (Fourdrinier) Committee during the convention and mentioned the features of interest in each of the four sessions.

For the coming year, the committee will continue to utilize questionnaires to summarize topics under the consideration of the group and present the summaries as a nuclei for discussion meetings open to members who have contributed by answering the questionnaires.

A discussion followed in which committee members suggested various subjects that might be considered during the coming year.

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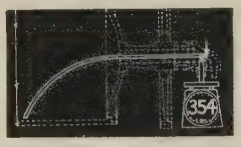

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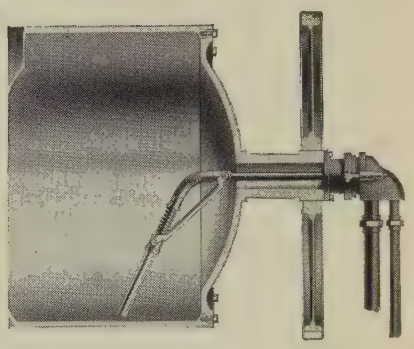

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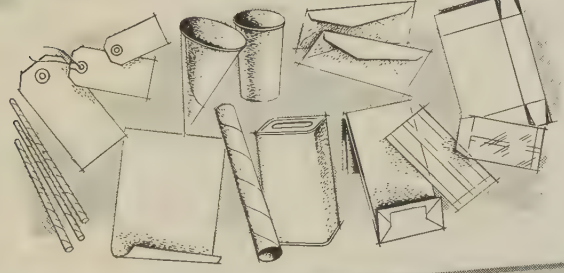

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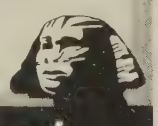

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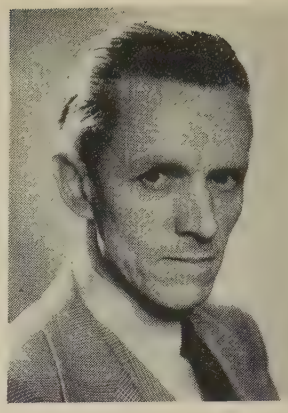
W. D. Harrison, Riegel Paper Co., Chairman, Pulp Purification Committee



E. C. Jahn, College of Forestry, State University of New York; Chairman, Plastics Committee

The following topics were considered:

1. Methods for controlling basis weight during paper machine operation.
2. The effect of closed white water systems on machine operation and final sheet properties. It was suggested that an engineer be assigned to tour the interested paper mills to aid in completing such a questionnaire.
3. The study of "curl," its causes and cures.
4. The study of erasure and methods of improving this paper property.
5. The development of a uniform formula for paper machine efficiency.

The greatest interest was exhibited in the suggestion of a study of closed white water systems. The committee indicated that such a questionnaire should include references as to the effect on sizing and the use of fortified sizes, the effect on felt condition, and the use of automatic pH controls. This questionnaire, together with the questionnaire on "Determination of Paper Machine Efficiency," will be prepared as soon as possible. All interested members of TAPPI are urged to communicate with either the committee chairman or the secretary in regard to the above questionnaires suggesting tentative questions or subjects under either topic that they feel should be covered by these questionnaires. There are a few copies left of the "Shake" Questionnaire, and in view of the fact that this topic will probably be carried over into 1952, the committee urges mill men who did not receive a copy of this questionnaire to write for a copy.

Considerable discussion took place on developing plans for a research project to be sponsored by the Fourdrinier Committee. It was felt that project laid out to determine some of the basic efforts of shake on the properties of paper, as well as fourdrinier operation, would be worth while.

During the convention interesting and informative programs were held on the subjects of "Importance of Shake," "Paper Defects—Causes and Cures," and "Tissue Machine Operation."

ROBERT G. HITCHINGS, *Secretary*

Pulp Purification Committee

The meeting of the Pulp Purification Committee was held on February 18 in the Commodore Hotel. The members present were John Noble, John Schuber, Vance P. Edwardes, J. N. Swartz, Robert L. McEwen, Ray S. Hatch, and Ward Harrison. R. H. McKee and Joe Perkins both sat in on the meeting.

It was decided that the present Pulp Purification Committee would be disbanded when the manuscript for the book on bleaching was complete and in the hands of the printer. The problem then confronting the committee involved its successors. It was suggested that someone be appointed to actively take over the chairmanship of the committee during the

interim period and try to develop new goals and objectives for the committee. Robert L. McEwen was unanimously elected to this position. It was suggested that the new objective for the committee might well be a critical examination of the pulp requirements for nitrating and dissolving pulps.

It was also proposed that the committee concern itself with developing an up-to-date bibliography on bleaching. This subject, however, was not regarded seriously by most members inasmuch as several had the impression that The Institute of Paper Chemistry was doing this work. Very little discussion took place concerning the present 12 chapters. It was reported in this meeting that three of the chapters had been set up in galley proof, eight chapters were in TAPPI's hands, and one chapter was still being worked on. Meetings took place during the convention between the various parties interested and the Editor to get the last chapter completely set up.

The committee would like to urge everybody on the present Pulp Purification Committee to contact Mr. McEwen if they have any ideas concerning the work to be done by the new committee. Mr. McEwen's address is 47 Meadowbrook Road, Williamsville 21, Buffalo, N. Y.

WARD D. HARRISON, *Chairman*

Plastics Committee

The Plastics Committee met during the afternoon of Feb. 18, 1952, beginning with a series of round-table business discussions held by four of its subcommittees. Following the subcommittee discussions, the entire group met for a short business meeting of the Plastics Committee.

MEETING OF THE ENTIRE PLASTICS COMMITTEE

E. C. Jahn, Chairman, briefly reviewed the year's activities. He then introduced L. K. Burnett, General Chairman of the Converting and Consuming Division, who described the function of the Division and the relation of the Plastics Committee to it. He welcomed any suggestions that would strengthen the Division and assist the several committees in performing their functions.

Twenty-one members of the Plastics Committee, together with approximately an equal number of visitors, attended this meeting.

Fall Paper-Plastics Symposium

The Fall meeting for this year was discussed. Herman Mark, Chairman of the Resins Advisory Subcommittee, stated that he would be glad to arrange a one-day session dealing with new developments in plastics and their relation to paper. Ralph Nazzaro, Chairman of the Subcommittee on Plastics in Paper Converting, also offered to arrange a one-day session dealing with the application of plastics to paper. It was agreed to hold a two-day Paper-Plastics Symposium at the State University of New York, College of Forestry, Syracuse, N. Y., on Nov. 5 and 6, 1952. It was further agreed that this Symposium be built around the above proposals of Messrs. Mark and Nazzaro, with a group of papers each morning followed by a panel discussion each afternoon. This procedure proved very successful last year. The Chairman, together with Messrs. Mark and Nazzaro, is to proceed with the development of the program.

Reports from Subcommittee Chairmen

1. H. Mark, Chairman, Resins Advisory Subcommittee—the subcommittee will assist in developing the Fall symposium.

2. W. S. Grimes, Acting Chairman, Subcommittee on Fabrication and Structural Products—there is a need for standardized paper tests for use by the papermaker when making saturating grades.

3. F. A. Simmonds, Chairman, Subcommittee on Cellulosic Materials for Plastics—the subcommittee desired to

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have the project "Interpretive Review of Literature on Pulps for the Viscose Process" reviewed by TAPPI for activation.

4. S. E. Church, Chairman, Resin Analysis Subcommittee—reported on the possibility of coordination with similar committees in other industries and with ASTM. Some means of keeping Mr. Shaw's bibliography up to date was also desired.

5. R. T. Nazzaro, Chairman, Subcommittee on Plastics in Paper Converting—reported on (a) government barrier materials and specifications and (b) a research proposal on permeability.

Meetings of Several Subcommittees

Prior to the meeting of the entire Plastics Committee at 4:00 p.m., four of the subcommittees held round-table discussions, beginning at 2:00 p.m.

Subcommittee on Fabrication and Structural Products, W. S. Grimes, Acting Chairman

Since only one member, W. S. Grimes, was present, only an informal meeting was held. The nonmembers attending were H. A. Spencer, J. R. Arthur, and John T. Stearn. The principal topic discussed was the need for standardized paper tests for use by the papermaker when making saturating grades.

Subcommittee on Cellulosic Materials for Plastics, F. A. Simmonds, Chairman

Members attending were: R. S. Apple, R. C. Blume, G. A. Day, M. A. Heath, A. T. Maasberg, M. O. Schur, F. A. Simmonds, and Peter Van Wyck. Also in attendance during a good part of the meeting were E. C. Jahn, Chairman of the Plastics Committee, and L. K. Burnett, General Chairman of the Converting and Consuming Division.

In connection with the subcommittee's proposal of March 6, 1951, for a committee project, "Interpretive Review of Literature on Pulps for the Viscose Process," to be financed by TAPPI, Mr. Jahn stated that, in general, literature surveys are not acceptable as TAPPI projects. However, because of the interpretive nature of this project he will ask for a reconsideration of the project.

The other topic dealt with was further consideration of the question of a change from subcommittee status to that of a separate committee. Mr. Jahn advanced the idea that subcommittee status would not restrict the scope of activity of the group. He further felt that there was much to be gained by having an integrated group dealing with all phases of polymeric substances, including the preparation of pulps for cellulosic products. Mr. Burnett felt, in principle, that organization should not be a bar or restriction on the activities of a group activity and that the best organization to achieve results should be agreed to. Mr. Jahn further pointed out that a larger group of related subcommittees enabled the successful organization of Fall meetings, which could not be accomplished otherwise. Members of the subcommittee present expressed their view that there was need for a TAPPI Committee on Pulps for Chemical Conversion. It was agreed that a formal request for full committee status would not be made for the present.

Subcommittee on Resin Analysis, S. E. Church, Chairman

Members attending were: C. E. Alexander, Q. C. Weaver, R. W. Reiter, and S. E. Church.

Means of continuing Mr. Shaw's "Bibliography on Resin Analysis Literature" to maintain it up to date were discussed. It was agreed to keep this bibliography up to date each year.

Coordination with similar committees was discussed. ASTM is actively working on analysis of polyethylene, vinyl resins, and plasticized vinyl resins. The Society of the Plastics Industry has developed flame test methods which will be adopted by ASTM.

It was agreed that the subcommittee should serve as a clearing house for resin analysis methods, including use tests, especially where the need for standardization is evident.

Subcommittee on Plastics in Paper Converting, R. T. Nazzaro, Chairman

Members attending were: Joseph A. Aid, Norman Greenman, Joseph Coleman, Paul Yoder, H. Lee Clack, George Field, and R. T. Nazzaro. Others attending were: L. Silvernail, C. Clark, F. A. Whitman, Owen Mosher, Robert Sturken, and William Thomas.

The subcommittee discussed the following topics:

1. Government Barrier Materials and Specifications. An active discussion was carried on the limitations of JAN-121-B as written (Feb. 18, 1952) and as proposed in the newly revised specifications. The principal aspect of this revised specification deals with the 5-hour turpentine test and the method for carrying out this test. It was felt that the revision did not corroborate actual service conditions any more than the 1800-second test. Mr. Thomas of Picatinny Arsenal indicated that the industry would have sufficient opportunity to offer their point of view before the revised specification is finally accepted.

2. Research Proposal. The research proposal on permeability was discussed and finally accepted by the committee present. A prospectus of the work to be included in this research was distributed among the members of this subcommittee along with the other members of the Plastics Committee as a whole present during the session.

It was felt that the proposal suggested to the Technical Association of the Pulp and Paper Industry would probably need revision in certain minor details after the project was finally accepted and discussed with the individual or individuals who will be responsible for carrying out the actual work. No action was taken on suggesting any place for carrying out this research until such time as TAPPI has had an opportunity to look over the proposal and approve it.

New Subjects: Fall Plastics Symposium. It was the feeling of the group that the Fall Plastics Symposium should be continued and in fact, the subcommittee offered its assistance in developing a program for the Fall. Robert Sturken had volunteered to write a paper on machinery for coating paper with plastics and in the near future Mr. Sturken will submit an outline of the proposed paper.

Plastics Session

The Plastics Committee sponsored a technical session which was held at 9:15 a.m. in the West Ballroom, Commodore Hotel, February 19. The attendance during the session varied from 100 to 150. The following papers were presented:

1. "Acetylation of Cellulose," by R. C. Blume, E. I. du Pont de Nemours & Co., Inc., Waynesboro, Va.
2. "Purified Hardwood Pulps for Chemical Conversion. I. Aspen Sulphite and Prehydrolysis—Sulphate Pulps," by F. A. Simmonds, R. M. Kingsbury, J. S. Martin, and E. L. Keller, Forest Products Laboratory, Madison, Wis.
3. "The Role of the Filler in Phenolic Laminates," by R. D. Fleck, Continental Diamond Fibre Co., Newark, Del.
4. "Polyamide Resin Suspensoids—A New Tool for the Paper Converter," by Harold Wittcoff, M. M. Renfrew, and Fred B. Speyer, General Mills, Inc., Minneapolis, Minn.
5. "Polyester Resins, Laminating and Molding Compounds," by M. H. Bigelow, Plaskon Div., Libbey-Owens-Ford Glass Co., Toledo, Ohio.

PLASTICS CONFERENCE

College of Forestry, State University of New York

Syracuse, N. Y. **Nov. 5–6, 1952**

LOCAL SECTION ACTIVITIES

Reports of Meetings, Personnel, and Events

Ohio

The Ohio Section met at the Chillicothe Paper Co. in Chillicothe, Ohio, on April 8, 1952. Approximately 175 members were present for the meeting. During the afternoon the Section was the guest of the Mead Corp. (Chillicothe Division) and the Chillicothe Paper Co. during tours through these respective plants.

Following dinner in the Chillicothe Paper Co. Cafeteria, Herb Smith, Section Chairman, introduced H. E. Whitaker, President of the Mead Corp., who briefly welcomed the Section members and guests to Chillicothe. Mr. Whitaker noted that there had been many changes in the Mead Corp. since the Section members had formerly visited Chillicothe. The group was told that Mead is building a new million dollar research laboratory in Chillicothe in the near future to augment existing facilities of Research, Development, and Technical Service.

Ohio Section members in the cafeteria of the Chillicothe Paper Co. at the April 8 meeting

The chairman then introduced F. L. Zellers, Mill Manager of the Chillicothe Paper Co., who in turn welcomed the guests and expressed the hope that they had had enjoyable and informative tours during the afternoon. Kenneth Geohegan, National President of TAPPI, was also introduced.

The report of John Clouse, the Section Program Chairman, was heard. The next meeting will be held May 8 at the Manchester Hotel in Middletown, Ohio. Entertainment before and after the dinner is scheduled.

The report of Art Thurn, Chairman of the Nominating Committee, was also heard. Those nominated were for Chairman, Ed. Brandon, Howard Paper Mills; for Vice-Chairman, John Clouse, Oxford-Miami Paper Co.; for Recording Secretary, George Gregg, Cincinnati Gas and Electric Co.; for Corresponding Secretary, Russ Buck, Sorg Paper Co.; and for Treasurer, R. D. McCarron of Stein Hall Mfg. Co.

The speaker of the evening, Carleton L. Clark, of the Clark and Vicario Co., was introduced by the April program chairman, J. F. Stevenson of the Mead Corp. Mr. Clark spoke to the Section of the Deculator, a paper stock deaerating device, developed and built by the Rotareaed Corp. The Section members were given an opportunity during the afternoon visit to the Chillicothe Division of the Mead Corp. to see a Deculator in action on the no. 11 paper machine of this mill.

Mr. Clark began his remarks by giving a brief history of the development of the Deculator. This equipment was first installed on a Canadian newsprint machine of the International Paper Co. in January, 1950. The following improvement was noted in the operation as a result of using deaerated stock:

1. The moisture content of the sheet leaving the couch was reduced by about 1%.
2. The air permeability of the sheet was decreased by about 25% using the Gurley Densometer test.
3. The surface smoothness on both wire and felt side was increased up to 19%.
4. Lumps and slime were reduced resulting in safer operation, and it was possible to maintain a cleaner headbox requiring fewer wash-ups.
5. After a new headbox was installed on the machine equipped with a Deculator, the sheet density increased still further.

Since this first installation, four more Deculators have been installed on newsprint machines.

Three more Deculators have been installed on paper machines making 0.009 corrugated medium from semichemical pulp. The installation of the Deculator on the first machine on this grade resulted in a machine efficiency improvement making possible a 200 f.p.m. increase in speed. The other two installations are at another mill of the same company; in these latter cases foam was reported to be eliminated along with slight increases in speed and a safer operation.

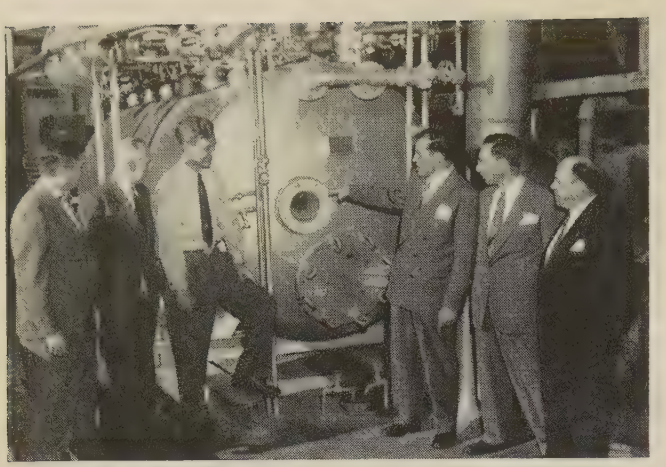
Another Deculator has been installed in a kraft bag mill on the Gulf Coast, where foam was a severe problem. Along with a better operation, the foam was eliminated and the headbox pressure and basis weight variations reduced.

Another Deculator has recently been installed on a kraft bag machine in Crossett, Ark., resulting in safer operation, a reduction in air permeability, better formation, and less weight variation.

Only the Mead installation has so far been disappointing, due possibly to the face that the stock has the smallest amount of air of any of the paper machines on which the Deculator has been installed. The Mead installation, has, however, apparently reduced foam and lumps and has been somewhat effective in reducing slime. Ten Deculators are in operation to date.

The operation of the Deculator was explained with the aid of a chart by Mr. Clark. The Deculator consists of a tank, to which stock is pumped, through headers and then through orifices which spray the paper stock at 700 g.p.m. each against

F. L. Zellers, Mill Manager, Chillicothe Paper Co., explains operations at his mill during the afternoon of April 8, 1952, to Ohio Section members



Inspecting the Deculator in the Mead Corp. mill are: Herb Smith, Mead Corp.; K. P. Geohegan, Howard Paper Mills, Inc.; C. L. Clark, Clark & Vicario Co.; J. F. Stevenson, Mead Corp.; J. H. Tate, Howard Paper Mills, Inc.; and R. D. McCarron, Stein Hall & Co.

stainless steel impingement plates. A vacuum sufficient to boil the stock at the existing stock temperature is required. The vacuum on the Deculator tank is maintained by means of a steam ejector connected with two Nash pumps in series.

The deaerated stock flows from a Deculator to a fan pump provided with special seals at the stuffing box, also having a large inlet eye for low inlet velocities and low specific speed. The general flow of stock may show some variations between installations, but in general, the stock flows from the machine screens to the Deculator, thence to the special fan pump, and then to the head box of the paper machine.

The power requirements for the Deculator are approximately 100 hp. for each 5000 g.p.m. flow. The cost varies between $30,000 and $100,000 depending on the flow volumes required.

Mr. Clark stated frankly that the Deculator was in the developmental stage and that there were still many unanswered problems as to the effect of deaeration on paper machine performance and paper quality.

Mr. Stevenson thanked the speaker for the Ohio Section and expressed the appreciation of the group for the interesting and informative talk given by Mr. Clark.

E. H. Shriver, *Recorder*

Empire State Metropolitan District

The Metropolitan District of the Empire State Section held a regular meeting at Fraunces Tavern, New York City, on Tuesday evening, April 15, with Chairman Willets presiding. About 50 members and friends attended.

After the usual introductions the chairman announced the forthcoming meeting of the Empire State Section at Niagara Falls, Ontario, June 19–21 and the Jubilee Meeting of the American Society for Testing Materials in New York City, June 23–27.

The report of the nominating committee (Messrs. Perry, Ekholm, and Emerson) was read. The slate for the coming season is: Paul L. Haggerty of George La Monte and Son, Nutley, N. J., for Chairman, Ralph Kumler of American Cyanamid Co., New York, N. Y., for Chairman-Elect, and John H. Doherty of Union Bag and Paper Corp., New York, N. Y., for Secretary-Treasurer. No additional nominations were made from the floor and this slate was unanimously elected.

The speaker of the evening, A. G. Lynn of the Products Development Department of Robert Gair Co., Inc., gave an unusually interesting talk on containers covering a number of controversial points. His remarks follow:

Remarks by Mr. Lynn

"Your committee has assigned to me for the evening a discussion of corrugated vs. solid fiber, fourdrinier vs. cylinder, kraft vs. jute, and, finally, a discussion of the various characteristics of corrugating mediums.

"As for the controversy of corrugated vs. solid fiber, I think the membership will understand that wherever weight is a factor, the lightweight corrugated materials will be used and solid fiber would not be considered as the weight differential is highly in favor of corrugated mediums, even to the extent of double wall being comparable in price and lower in weight. Economically, if corrugated will do the job of retaining the load and protecting it, solid fiber very definitely falls by the wayside and is not considered. It is a very indisputable fact, statistically, that solid fiber remains at a steady level of production without increasing or decreasing appreciably through the years, whereas corrugated has increased steadily until it is nearly eight times as great today as it was in 1925.

"It must not be forgotten that the solid fiber V board boxes used during the war to transport subsistence items to the front were one of the secret weapons which did so much to overcome supply difficulties to our troops and to the troops of our allies. It must also be remembered that where excessive humidity is present, such as in export containers, solid fiber will always have a place that cannot be taken by corrugating mediums as we know them today. We might sum this up by saying that certain jobs will always fall in the lap of solid fiber and others will fall to corrugated, but that the increasing uses of solid fiber simply replace other uses as they fall by the wayside. However, with corrugated many new uses seem to be found which keep pace with the increased production of linerboard.

"As for the argument in the second part of the discussion, fourdrinier kraft vs. jute or cylinder liners, a study of the characteristics of a fourdrinier kraft 42-lb. liner shows besides a basis weight of 43½ lb., caliper of 0.014, a burst of 106, a G.E. puncture of 35 units, the interesting characteristic of tear in the machine direction of 360 g. per sheet and across the machine direction 390 g. per sheet. Fourdrinier kraft in 47-lb. water finish will have a basis weight of 48–50 lb., a caliper of 0.016, a burst of 104, a G.E. puncture of 39 units and again an interesting tear in the machine direction of 430 and across the machine 435. When we compare the cylinder jute liner, semiwater finish, which has a basis weight of 54.9, a caliper of 14.8, a burst of 93, a G.E. of 33 and find the Elmendorf in the machine direction 180 and across the machine direction 362, we can readily see that someone is going to wonder about tear along the score or at least one direction of a jute liner. Substantially the same thing occurs, although perhaps a slight improvement is found with a cylinder kraft liner over the jute. The basis weight will be slightly less whereas the caliper a bit greater and burst a little higher. The G.E. will be substantially higher and the Elmendorf will be a little better than is found with the jute liners. However, because again it requires nearly 25% additional weight with a

W. R. Willets, Titanium Pigment Corp.

A. G. Lynn, Robert Gair Co.

cylinder or a jute liner to match burst characteristics and G.E. puncture, it will probably be the future of jute and cylinder board that as long as fourdrinier kraft is readily available, it will stand in the shadows because there does not seem to be any justification, with one possible exception, for considering jute. This exception would be found in the smoothness and density of the surface layer, especially on water finish boards or semiwater finish boards with consequent improvement in printing characteristics for a quality appearance.

"It is the writer's opinion that jute and cylinder board are too stiff and brittle and that the wanted stacking strength is so little greater than can be found with properly fabricated fourdrinier kraft materials that the customer will, when he studies the problem, very seldom be willing to pay for the additional weight involved. Of course, there is the problem of what to do with wastepaper and should the market for this commodity be easy and steady, there will always be a certain number of jute liners manufactured. I cannot resist adding that I certainly hope these will be manufactured in the best possible tradition of the craft and that the boards resulting will be as superior as we were accustomed to receiving in the good years before World War II.

"As for the last part of the talk that has been assigned to me, I would draw your attention for statistics to three studies which have been made at The Institute of Paper Chemistry, Appleton, Wis. Statistics are found in the report to the Fourdrinier Kraft Board Institute, Report No. 2, entitled 'A Study of Paperboard Quality as Related to Fiber Box Performance' dated August, 1947. Also, the figures found in Report No. 3 to the Jute Research Group entitled 'The Effect of Liner Weight on Combined Board and Box Performance.' In these studies you will find a breakdown of various corrugating mediums and a study of their effect upon the various characteristics as measured by several standard measures of box performance. A careful study will indicate rather strongly that the characteristics to be found in kraft and chemfiber seem to indicate a certain superiority of these mediums for corrugating. For my personal view, I am inclined to class the corrugating mediums in the following order: (1) fourdrinier kraft, (2) chemfiber, (3) chestnut, (4) straw, (5) bogus. There will be many who will quarrel with this classification, and I acknowledge that some measures of box and board characteristics seem to indicate a superiority of straw above the others. However, after many long years, I am inclined to ignore these measures and place the most value on G.E. puncture with other tests taking a lesser importance.

"For the third comparison, I would suggest a comparison of liner variability as reported to the Jute Research Group by The Institute of Paper Chemistry, Oct. 15, 1950. As soon as these three reports have been studied, one thing comes to mind very clearly as a simple cure for the ills which beset the boxmaker who is seeking the easiest answer to the improvement of quality. He can see rather readily that by adding 2 to 4 lb. of paper per thousand square feet to the corrugating medium, he will discover such improved characteristics as are determined by his customer."

Although Mr. Lynn requested that certain of his remarks in the question-and-answer period that followed be kept off the record the ensuing discussion was of such interest that note should be made of some of the points raised.

As regards the relative place of jute and kraft it was pointed out from the floor that with the increasing shortage of "long fibers" and increasing labor and other operating costs in the deep south there would probably always be a place for jute in the container field.

The subject of corrugating adhesives was also discussed briefly and the opinion expressed that starch was superior to sodium silicates from an operating viewpoint. However it was pointed out that the availability and economics of starch were dependent on the over-all grain markets and fluctuated widely. In answer to a question from the floor Mr. Lynn stated that the viscosity of the starch adhesive played a large part in efficient operation of the corrugating machine and that it should be closely controlled to prevent sloppy, wet board.

M. Landberge, General Dyestuff Corp.; P. L. Haggerty, George La Monte & Son; A. G. Lynn, Robert Gair Co.; W. R. Willets, Titanium Pigment Corp.; R. W. Kumler, American Cyanamid Co.; and R. T. Bingham, TAPPI

It was the general consensus that certain test methods had little application from an end-use viewpoint and that "Rule 41" applying to rail shipments needs revision to make it more practical by removing from it specifications which have little or no meaning. It was noted that certain tests such as the puncture test, folding test, beam deflection test and crush tests probably have more direct application to end use than some others commonly employed. Both TAPPI and ASTM have committees actively engaged in paperboard and container testing and these groups form logical means of rationalizing existing test methods and specifications, and developing new ones.

The opinion was expressed that most container failure occurred from mishandling in the shipper's plant and from improper car-loading, rather than from under-packaging. It was stated that as a matter of fact if proper precautions were used in handling and car-loading many shipments were actually over-packaged rather than under-packaged. The importance of proper education and supervision in handling shipments on conveyors within a plant, and in car-loading, was emphasized but there was a difference of opinion as to whether such education and supervision could be effected. At any rate until such conditions are remedied it will probably be necessary to over-package to compensate for them. Also while a container might meet the same "test" under Rule 41 it might represent over-packaging for shipment of certain material and under-packaging for another type of merchandise.

A rising vote of thanks was extended the speaker.

W. R. Willets, *Chairman*
L. E. Georgevits, *Recorder*

Empire State (Eastern District)

The Eastern District, Empire State Section, met at Milfrank's Restaurant, near Glens Falls, N. Y., on March 27, 1952. C. N. Hager, Jr., presided at a panel discussion of "Pitch Control."

Participating as panel members were D. D. Linehan, West Virginia Pulp and Paper Co., Mechanicsville, N. Y., who discussed "Pitch Control Problems." Herbert F. Jacques of the Diamond Match Co., Plattsburg, N. Y., presented "Notes on the Diamond Match Co. Pitch Treatment." Robert Maynihan of Finch, Pruyn Co. discussed "Can Pitch in a Paper Mill Be Controlled?" and Frank J. McCourt, Jr., of the International Paper Co., Palmer, N. Y., discussed "Pitch Control."

Remarks by Mr. Jacques

"Above five years ago, an article in the *Canadian Pulp and*

Paper Magazine mentioned the successful use of the various phosphates in the control of pitch in the Canadian newsprint mills. We decided to try some of these materials in our own groundwood mill at Plattsburg. A small supply of tetrasodium pyrophosphate was secured and a short mill trial was run. The methods of preparation and application as outlined in the article were closely followed, but the results were not particularly encouraging and the treatment was discontinued. However, shortly after this trial in the groundwood mill, we experienced considerable pitch trouble in the paper mill. We tried adding a small amount of dry TSPP in the beaters and the results were so encouraging that a more lengthy trial was decided upon.

"An attempt to secure sufficient TSPP for a mill trial was unsuccessful. The material was not available in the quantities necessary. Thus began a search and trial of a large number of the various phosphates on the market. We ran short trials using various trade name pitch treatments as well as the different phosphates. Some of the materials gave some help in pitch control, others did not seem to have any effect at all on the pitch, while others actually made the condition worse. Eventually, we were able to secure a good supply of TSPP and began a long mill trial which has finally developed into our primary pitch treatment.

"The use of TSPP for pitch control required a slight change in our paper furnish. We have found that alum seems to reduce greatly the efficiency of the TSPP as a pitch controlling medium. Thus we have had to eliminate the use of alum in all furnishes, except those which require this material, such as rosin sized and wet-strength papers.

"A little over a year ago, another material was found which gives us good pitch removal. Up to that time, this particular material had not been used, to my knowledge, for pitch control. We noted the pitch dispersing properties of this material quite by accident and a trial on the paper machine confirmed the fact that this material was very effective in removing pitch deposits from the paper machine wires and felts.

"A third material which we use in the mill for pitch control is the solvents. These chemicals, Savasol and Xylol, are very effective when sprayed directly on the return side of the wire through a spray pipe and on the felts in the same manner.

"Thus our pitch treatment consists of three different chemicals, phosphate, TSPP, our dispersing agent, Keraton, and the solvents.

"The preparation and application of the treatment are quite simple. Our pitch treating solution is made up by dissolving in warm water a definite amount of TSPP and our dispersing agent in a 750-gallon tank. It is important that the solution not be heated too high, otherwise the TSPP will revert to a less effective material. The unbleached sulphite in the hydrapulper is treated with a definite amount of the solution. The stock, after bleaching, receives a second treatment at the discharge end of the alkaline washer. The paper machine treatment is at the stock regulators.

"Treatment at the hydrapulper is necessarily batch-wise, while that at the alkaline washer and on the paper machines is continuous through a metered orifice. Our pitch treating solution contains about 5% solids with the TSPP and the dispersing agent in a ratio of five to one.

"Our total treatment to the stock is at about 0.3% rate and is continuous. Even with this continuous treatment we sometimes have troublesome deposits of pitch on the wires and the felts. When this deposit occurs we resort to our solvent treatment, which is quite simple and generally very effective.

"The solvents are contained in a large tank mounted on a wheeled dolly, complete with its own pump and motor, which can be moved to each machine as needed. The material is pumped through the shower pipes covering the return wire and/or the felts. The advantage of this treatment is the fact that it can be applied 'on the fly' without any down time and consequent production loss. The amounts used are generally small, 5 to 10 gallons, and the residual carry-over in the sheet is removed in going over the driers. The disadvantage of this treatment is the fact that while the solvent does dissolve the pitch from the wire and felt, the dissolved pitch is still in the system and can return to the wire or felt and again cause trouble. However, despite this disadvantage, this treatment is very effective.

"There are times when our TSPP dispersant solution and even the solvents will fail to remove the deposits from the wire. These particular troublesome deposits seem to be a combination of pitch and small bits of stock embedded into the wire. We have been quite successful in removing such deposits by the addition of additional dispersing agent (Keraton) dripped into the stock regulator or headbox of the paper machine in a continuous stream.

"We have found that we can remove pitch deposits from the wire 'on the fly' by the addition of 'slugs' of our TSPP dispersing agents to the headbox of the paper machine. This treatment is much slower in action than is the solvent treatment, but it is as effective given a bit more time than required for the solvent treatment.

"We have found that we can clean dirty, pitchy felts 'on the fly' by the addition of additional dispersant at the stock regulator or headbox of the paper machine. On several occasions, it has been noted that it was necessary to cut off steam into the drier to prevent overdrying of the paper when using the dispersant at the headbox.

"A word about equipment to handle phosphates may be in order. We have found plain iron pipe and pumps to be the best material to resist the corrosive action of the phosphate solution. However, this is not completely satisfactory. Our large, iron dissolving tank which has been in service for about four years is now developing leaks. Our piping system to the machines is also causing some trouble. We are investigating Tygon paints for the large tank and plastic piping for the dispersing system. However, we have no definite answer regarding the resistance of these materials to phosphates as yet.

"We are continually experimenting and looking for a better treatment for pitch control. At the present time, we are evaluating in the lab a very large number of chemicals. At the end of this lab trial, we expect to choose a few of the better materials and run mill trials of sufficient length to thoroughly evaluate the materials against actual mill conditions. Our past experiences with phosphates and other various chemicals have been a great aid in controlling the ever-present pitch trouble on the paper machines, but there are many questions to be answered yet.

"Only by the continued experiments and trials by paper mill chemists, technicians, and the chemical suppliers will these answers be found."

Remarks by Mr. Moynihan

"The subject of this paper 'Can Pitch in a Paper Mill Be Controlled' is a good question. We do not have a definite or a complete answer, but feel we have made some progress in keeping our mill system free from pitch.

"In the newsprint days at Finch, Pruyn pitch was a major problem. In those days we had old concrete chests which were exceedingly pitted and, naturally, a fine location for pitch build-up. With these old chests, the agitation was very poor. All of the stock and white water lines were made of iron pipe and fittings. This combination was ideal for pitch deposits. We tried to combat the pitch situation with every type of pitch control product on the market, with very little success.

"The modernization of the mill to produce groundwood printing grades included all tile-lined chests with excellent agitation. Transite pipe was installed throughout the mill on all the stock and white water lines. These improvements alone could not cure a pitch condition, but have helped a lot.

"We feel a long step toward pitch control was taken when we instigated pH and acidity tests around the clock. The groundwood white water is treated with liquid caustic through a rotameter and the pH is controlled in the range 5.8–6.2 with a resultant acidity 10–20 p.p.m. At the present time, we are treating the paper mill white water with a dry lime feeder and controlling the pH and acidity in the same range as the white water in the groundwood mill.

"Very shortly, we are converting our control of the paper mill water to a caustic addition in order to eliminate mechanical troubles with the dry lime feeder.

"As our mill system is entirely closed, we feel that this close control of pH and acidities has greatly benefited our operations. We find, if the pH and acidity vary too much out of the specs we have set up as controls, we have a pitch problem with the resulting wire, felts, and press roll cleaning. We feel that this close control keeps the pitch dormant in the mill system. We know we have pitch present because, when we take a transite pipe apart, we find a coating of pitch deposited on the iron connections, although the transite pipe itself will be entirely free of any deposits.

"We might mention here an added advantage of close control of pH and acidities has helped our sizing problem tremendously; to amplify, we have a uniform stock for sizing purposes, which results in more uniform sizing in the finished sheet.

"We now come to what we consider the major feature of pitch control 'good housekeeping.' The stock chests and white water lines are washed every Sunday, with the high-pressure hoses.

"As we purchase all of the chemical pulp used in the mill, we feel that the chests used for this pulp require additional attention.

"We have three separate systems for chemical pulps, one for each machine. Our pulping equipment consists of a 2500-lb. Hydrapulper and four Mordens for refining. The three systems are rotated for cleaning, one each Sunday. One half per cent caustic, made up to 8000 gal. heated to 120 to 140° F. is prepared in the Hydrapulper and flushed through the Mordens into the chest to be cleaned. From the chemical pulp chest, it is pumped to the blending mixer and then to the paper machine chest. With a special connection used just for this purpose, the hot caustic is pumped to the suction boxes and headbox, thus completing a thorough wash-up. After flushing the system out with hot caustic, it is then rinsed with fresh water to remove the caustic residue.

"From our experience, we believe that pH and acidity control are very important, but too much emphasis cannot be placed on 'good housekeeping.' For the past six years, since our modernization program was started and completed, with the pH and acidity controlled and by effectively cleaning the mill system, we have been completely free of pitch troubles."

Remarks by Mr. Linehan

"Your moderator, Mr. Hager, called me some three or four weeks ago, and asked me if I would be willing to sit in on a panel discussion of this very controversial problem of pitch control.

"I told him I would discuss it with management and he would be advised. Management, in its inimitable way, surveyed the field and decided that I knew the least about it of anyone in our organization and, being considered the one most unlikely to succeed, was told to go ahead. So, here I am.

"We have no pitch problems. Later on I will tell you what we are doing, and what we are using, in an attempt to keep ourselves out of this pitch trouble. You have heard various speakers mention the ray cells in wood which are generally considered to be the source of all pitch. Well, one thing about West Virginia, we have always been extremely careful about the kind of wood that we buy and take in and, either there were never any ray cells in it, or they were removed before it was brought to us.

"However, about two years ago, we ran into quite a bit of pitch difficulty and decided to do something about it in a big way. So, we went way back to the sulphite digesters and added a dispersant furnished by a large oil company. Everything was fine—pitch remained steady and constant, and so we were not upset. But we cut out the dispersing agent, and the pitch disappeared, and we have never been bothered with it since. If anyone has a pitch problem, I would certainly recommend this treatment. It sure worked for us.

"Now, we have never had any kind of a pitch problem in the sulphite mill, so let's stroll down to the paper mill. Down there, everything that is bad comes from the pulp mill, and the good things are added at the beater room.

"Theoretically, the phosphates are the complete answer to our problem. Our conditions are perfect, and everything is lovely, but, gentlemen, the phosphates do absolutely nothing for us. We have used diatomaceous earth with some benefit, but the end result is still questionable.

"In the organic dispersant field, both Nycol and Tamol do seem to give us some assistance. We are using them in small quantities. Fleetone is possibly also some help.

As for seasonal difficulties, we seem to keep this pitch business so well dispersed that it does not come all at once, but is continuous.

"And now, if we do have a sizable amount of pitch in our stock, it is something we cannot see, and we do not think our customers can either, and we believe we are therefore in a rather enviable position of being able to sell it, which is, after all, the end result we are striving for."

Remarks by Mr. McCourt

"In our pulp and paper mills we feel that we do not have a serious pitch problem, at any rate not serious enough to use any of the control chemicals which are available. This does not mean that we cannot find pitch in the system if we look for it. It does mean that there is little evidence of pitch in our paper and that the shutdowns to get pitch spots off the wires of our paper machines are infrequent. When pitch does show up it is usually on one machine only and is of short duration.

"There must be some reasons for not getting pitch as well as there are reasons for getting it. Frankly, I am not sure why we are not bothered. My first thought is that it may be due to control of our wood consumption. Normally we carry a large inventory of wood in the yard so that it is usually unnecessary to use green wood which undoubtedly is a source of pitch. Occasions do arise when, in an effort to keep rough wood out of our piles, the percentage of green wood consumption gets rather high. Then there does appear to be an increase in pitch on the groundwood deckers, but before anything conclusive can be established the papermakers are raising a howl about the poor stock that they have to use. This pressure, when put on the wood yard, results in a decrease in green wood consumption.

"As mentioned before, pitch appears in the groundwood mill on the deckers. Inasmuch as we have ample decker capacity the stock can be shut off a decker at any time, and the pitch blown out with a high-pressure hot water hose. If conditions get too bad the decker can be boiled out with a soda ash solution. We have had one experience with excessive pitch which started when we began to use one type of slime control chemical and ended when we stopped using the chemical. Since it may have been happenstance it seems only fair to eliminate the name of this slime control chemical.

"In the sulphite mill, pitch appears at two points, one is on the whipper shaft which breaks up the stock as it leaves the cylinder of the unbleached decker; the other is on the side walls of a screw conveyor which moves stock to the high-density bleachers. The only similarity of these two spots appears to be in the physical action, probably best described as squeezing, on the pulp. The whipper shaft is copper covered; the side walls of the conveyor were rubber-lined but are now

Mr. & Mrs. R. M. Drummond, Mr. & Mrs. R. B. March, and Mr. & Mrs. H. H. Lavery

stainless steel, so I cannot accept any theory of electronic deposition in these instances. We have not tried to eliminate these conditions because the build-up is never severe enough to worry about its dropping off and contaminating the stock. The build-up is greater on the screw conveyor and we have pulled it off on occasion but certainly no oftener than once in two years. Decker wires show indications of pitch spots but our cleaning procedure of blowing them out once a week has proved adequate.

"Pitch in the paper mill appears on the machine wires and press roll doctors. It has been our practice for years to add caustic to the unbleached sulphite pulp in the storage chest ahead of the beaters. The caustic addition is equivalent to 0.05 lb. per ton of pulp and is used as a pitch control agent. If pitch does appear on the machine wires we shut down the machine and swab some kerosene on the spots and then blow them out with a hot water hose.

"I recall one experience we had with pitch on one of two machines running side by side with the same furnish, same speed, and practically identical conditions. The pitch accumulated on the doctor blade of the second press on one machine but there were no signs of it on the other machine. The difference in the two machines was in the top press rolls—where the pitch accumulated we had a brass-covered roll while the other machine had a granite roll. When we changed the brass roll and put in a granite roll, we eliminated the pitch. Unfortunately the third press roll was also brass covered so the pitch built up there until we changed to a granite roll in that position. I would like to point out that there is a squeezing action on the stock at the point where the pitch is deposited which in a sense corresponds with the screw conveyor action in the bleach plant. Of course if this physical action does augment pitch build-up, the only reply is 'so what' as there does not seem to be any way of eliminating that action from the process of pulp and papermaking.

"Recently we have had a siege of pitch accumulating on the calender stack where it has been a grade-A nuisance as it drops off and gets embedded into the sheet. We feel that this was due to an excess of green wood but why it should miss all the other spots and collect on the calender rolls we are not ready with an answer.

"This started out as an explanation of why we do not have pitch but it turns out that there are spots where pitch does accumulate and become a nuisance. In some operations this much pitch might be considered as a serious problem but in ours we continue to look upon it more as a nuisance. In the final analysis the cost of pitch control has to be justified by an increase in the amount of salable paper which leaves the mill."

Following these talks there was a lively discussion of the suggestions made by the speakers.

HUGH LAVERY, *Recorder*

Meeting of April 17, 1952

The Eastern District of Empire State TAPPI held a meeting April 17, 1952. This meeting was an annual "Ladies' Night." The 87 persons attending enjoyed the color movie, "The du Pont Story." Door prizes, contributed by du Pont, Hercules Powder Co., and Becco, were distributed prior to the movie.

On May 22, 1952, Jess Oren of Armstrong Cork Co., Lancaster, Pa., discussed "The Drying of Paper."

R. D. LEWIS, *Recorder*

Chicago

A scientific knowledge of the characteristics and effects of odors can be put to advantageous use in the paper industry. This was the theme of a talk, "The Nature of Odor," given March 17 at the monthly meeting of Chicago TAPPI. Ernest C. Crocker of Arthur D. Little, Inc., Boston, Mass., was the guest speaker.

Outlining the basic facts known to scientists regarding the physical and chemical properties of "smells and smelling," Mr. Crocker declared that since the advent of the Pure Food and Drug laws, the sense of smell has become less and less necessary to detect spoiled and contaminated foods.

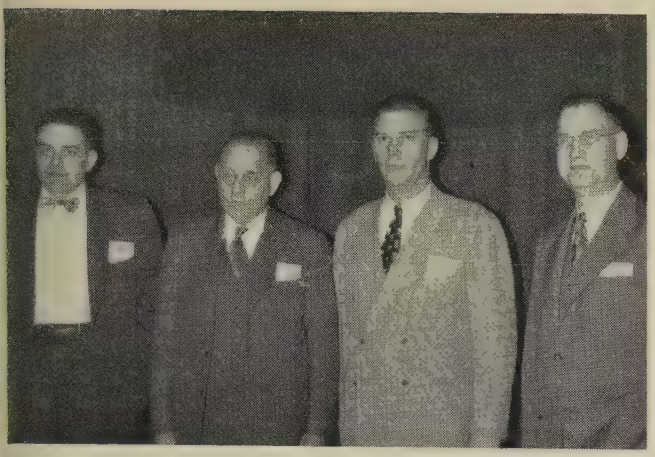
Whereas there are but four tastes, the speaker continued, there are thousands of different odors. These may be classified. The sense of taste is dependent on the sense of smell. We smell molecules of odorant, dispersed in air. There must be sniffing of the odorized air to properly "throw the air up to the smelling area." Mr. Crocker illustrated this part of the talk with slides. The size of the molecule of odorant influences its smellability. The strongest odors correspond to molecular weights in the range of 100 to 200, he said. The upper part of this range includes most of the difficultly volatile materials that tend to persist and are hard to eliminate.

Many materials, including basic food materials, in themselves have no odor, being nonvolatile. Fats and oils may oxidize and crack into smaller volatile fragments and develop odor. Proteins may generate odors if attacked by bacteria or if heated.

In the paper industry, Mr. Crocker stated, it must be remembered that cellulose itself has no odor or taste. Odoriferous paper is contaminated paper. It is important that food containers contribute nothing whatever to odor, he said.

Usually single odors, familiar or not, tend to stand out strongly and to be objectionable in all intensities. Mixed odors are better tolerated, and frequently will not be commented upon even up to fairly high intensities. This makes

The Chicago Section meeting dinner held March 17, 1952



Peter Trucano, Morris Paper Mills; E. C. Crocker, Arthur D. Little, Inc.; V. V. Vallandigham, Kelco Co.; and W. R. Price, Applied Research Service

possible the use of masking agents, which add complexity to the odor. Most odors disappear in time by evaporation, others may oxidize and disappear.

The speaker listed four methods by which various papers may be tested for retained odors: (1) by steaming the paper with the breath or otherwise dampening and sniffing immediately; (2) by placing strips in odor-free jars partly filled with water, closing the jar, and smelling and tasting the water after standing; (3) by sandwiching butter in the paper and tasting the outer layer of butter; (4) by placing the paper in a closed container which contains smaller containers of mineral oil and water, the sample being out of contact with the oil and water and then sniffing the oil and water.

A lively question-and-answer period followed the talk.

In charge of the meeting was Vance V. Vallandigham, Chairman of the Chicago Section. The speaker was introduced by Peter J. Trucano.

Meeting of April 21, 1952

Printability and other properties of paper are influenced very largely by the surface sizing materials used in papermaking. This was the theme of the panel discussion at Chicago TAPPI at the April 21 meeting. Well over a hundred were in attendance at this dinner and discussion meeting.

The panel was composed of:

Warren Kumblad, Staff Engineer, Chemical Products Div., of the Socony-Vacuum Oil Co.—Wax Emulsions.
James P. Casey, in Charge of Technical Service, A. E. Staley Mfg. Co.—Starches.
Harris Ware, Sales Supervisor, Paper Makers Chemical Div., Hercules Powder Co., Wilmington, Del.—Carboxymethylcellulose.
Vance Vallandigham, Chicago Sales Office, Kelco Co.—Sodium Alginates.

Mr. Kumblad stated that wax emulsions are composed of very finely divided waxes in water dispersion. The waxes used fall into three classes: (1) paraffin wax, (2) microcrystalline waxes, and (3) petrolatums.

Each of these types has a specific use. The paraffin wax emulsion is used where a dry appearance is desired. Microcrystalline waxes are used for flexibility and toughness. Petrolatums impart softness in addition to water resistance. All three classes impart water resistance. These dispersions may be also classified according to the type of dispersing agent used:

1. Cationic, low pH, in the vicinity of three to four, acid in character.
2. Anionic, higher pH's, above seven, alkaline in character.
3. Nonionic, no charge, neutral in character.

In the paper industry where stability to acid papermaking chemicals would be desirable, the cationic type would be indicated. There, however, may be special applications where any one of the three might be indicated.

Very small quantities of wax emulsions are applied to the sheet, in the vicinity of 1 to $1^1/_2$% on the weight of the sheet. Actually the amount laid down is of the order of a monomolecular layer.

Mr. Kumblad stated that the advantages of wax emulsions over solvent or hot melt applications may be listed as follows:

1. Wax emulsions may be applied at room temperature.
2. Wax emulsions have a high solids content in the vicinity of 50%.
3. The water disperse phase is nontoxic and noninflammable.
4. No solvent recovery system is necessary.
5. The emulsion may be applied to a water-wet system.
6. The wax emulsion may be conveniently applied at the size press.

Mr. Kumblad also stated that wax emulsions may be applied in the stock beater and, in this application, it provides internal sizing to supplement rosin size for water resistance. When used in this fashion it may replace 20 to 40% of the rosin.

Mr. Kumblad listed the following properties which are imparted by wax emulsions:

1. Improved sizing and water resistance.
2. Reduction of foam since rosin is replaced.
3. More desirable finish, less surface fuzz, and better printability.
4. Better softness and pliability and foldability.
5. Reduction of curl in the cut sheets.
6. Reduction of rapid change in moisture content.

Mr. Kumblad stated that wax emulsions are used on the following types of paper with results noted:

Wallpaper—for improved drape and finish.
Map paper—for improved water resistance, drape, and folding.
Poster paper—for water resistance.
Butcher wrap—for water resistance.
Tablet paper—for reduction in curl and reduction in feathering.
Offset paper—for reduction in curl and reduction in surface fuzzing.
Drinking cups—for water resistance at high temperatures.

The above papers are treated by beater application.

Mr. Kumblad listed papers which are treated with wax emulsion by surface treatment such as a size press or calender stack application.

Candy cup stock—for slip.
Meat wrap—for water resistance.
Bag stock -for water resistance.

Warren Kumblad, Socony-Vacuum Oil Co.; V. V. Vallandigham, Kelco Co.; Peter Trucano, Morris Paper Mills; James Casey, A. E. Staley Mfg. Co.; and Harris Ware, Hercules Powder Co.

Part of the group at the April meeting of the Chicago Section

Twisting kraft or spinning kraft—for twisting properties.
Bristol board.
Folding boxes—for improvement of fold.
Corrugated liners.
Wallboard.
Tag stock.

Wax emulsions are also used, Mr. Kumblad stated, as modifiers in rubber latex sizing in papers. Here the wax emulsion acts as a detackifier and sun check resistor. Concentrations of 3 to 5% on the total weight of paper are used here.

Mr. Casey stated that starch can be determined in paper by a simple iodine test. This test, however, does not tell the true story as to how the starch got into the paper—whether applied by size press application, by calender application, by beater application, or whether or not it was present in re-used scrap stock.

Mr. Casey further stated that there are many different types of modified starches and that there are a number of methods of preparing modified starches. There are likewise a variety of viscosities available in starches.

Among the functions of starches in paper are the reduction of gloss ink absorption, reduction of surface fuzz, an increase in fiber bonding both at the surface and internally. One of the drawbacks of starches is its inability to produce flexible continuous films.

Mr. Casey also stated that starches are used in papermaking for their adhesive properties such as a binder in pigment coatings.

Mr. Ware outlined the chemistry of carboxymethylcellulose in some detail. He pointed out that cellulose itself is not water soluble and that the addition of carboxy-methyl groups to the cellulose group increased the water solubility of the combined group in proportion to the number of carboxymethyl groups added.

The viscosity of the finished material is controlled by varying the length of the molecular chain according to Mr. Ware.

Carboxymethylcellulose may be applied from calender stack or from the size press for improved surface fiber bonding.

Mr. Ware listed the following properties of carboxymethylcellulose:

1. Film forming.
2. Insoluble in grease and oil.
3. Fiber bonding.
4. Wide range of viscosities.

Normal concentrations for use are from $^1/_2$ to 2%. Ten per cent concentrations are used when a high degree of grease resistance or a high gloss is desired, Mr. Ware said.

Mr. Ware said that 2 lb. per ton of paper shows an improvement in burst of from 5 to 20%. This concentration gives a better wax pick test and improved resistance to ink penetration and to wax penetration.

Mr. Vallandigham stated that alginates are derived from kelp, a sea weed growing off the coast of San Diego. Alginates are classified as hydrophilic colloid, Mr. Vallandigham said. These materials show a high degree of resistance to filtration but at the same time they readily wet the surface. These colloids have polar characteristics.

He stated that the surface of the sheet is the property which most affects printability and the filming type of material is most effective for preparing the sheet for good printing results. The alginates may be applied from the calender stack or from the size press.

Mr. Vallandigham said that the alginates are useful in the making of waxing paper, milk bottle stock, as a presize for clay coating. The alginates are useful in laying down of the surface fibers—one pound of algin for 60,000 square feet of paper being effective.

He stated that he had done considerable work on printability and had developed an instrument which he called the Vanceometer. This is an instrument which reads and microamperes the light reflectance against time. The changes in the light reflectance of a controlled film of oil on a sheet are measured. A poorly sized sheet would show a rapid change in light reflectance and a well-sized sheet would show a slow change in light reflectance.

Mr. Vallandigham stated that the Vanceometer is useful at the mill in controlling the sizing operation and also at the printing plant to determine the sizing properties of the paper. It is useful on lightweight sheets as well as on board.

At the conclusion of Mr. Vallandigham's talk, a spirited question-and-answer period followed.

WARREN R. PRICE, *Chairman*
Chicago TAPPI Publicity Committee

Kalamazoo Valley

The Kalamazoo Valley Section of TAPPI and Michigan Division, American Pulp and Paper Mill Superintendents Association, held their annual joint meeting on coated papers at the Harris Hotel at 6:30 p.m., Thursday, April 17, 1952. Approximately 130 members and guests of the two organizations attended.

Dee James Andella, Illustrations Staff, *National Geographic Magazine*, Washington, D. C., spoke on the subject: "Multicolor Printing on Quality Coated Paper." This was followed by a panel discussion with the following members participating. Merle R. Wilkins (moderator), Kalamazoo Paper Co.; H. Ray Hall, Allied Paper Mills; Allen T. Luey, Sutherland Paper Co.; Harrison H. Kindig, Mac Sim Bar Paper Co.; Glenn Davidson, Aurora, Ill.; L. H. Mimms, Kalamazoo Paper Co.; and Jack Marks, The Upjohn Co.

Richard H. Peeters, Chairman of the Michigan Division, introduced John R. Dam, Chairman of the Kalamazoo Valley Section, and Merle R. Wilkins, Chairman of the meeting, introduced Mr. Andella.

Questions from the audience following Mr. Andella's talk, which is given in detail below, brought out the following points:

Recommended method of control on quality of coated papers delivered to printer is to obtain an advance skid of sheets representing all reams in the mill ready for shipment. Sheets and reams are properly identified so that printer may reject any reams that press trial shows below standard.

A preference was made for natural white stock for use in multicolor printing and blue-white for black and white.

The question of caliper tolerance on 65-lb. stock showed preference for not more than 0.0005 allowable variation.

Double-coated stock preferred over single. First coating, using starch, to be anchor or primer, followed by casein coat for printing. Two light coats were considered better than a single heavy.

Mr. Andella described the use of a thin rubber sheet under hard packing in make-ready, as a means of covering up for

paper irregularity and lack of resiliency. He also told of the use of small wedges placed on cylinders, in areas not printing, as means to taking up slack or ripples. Wedges are bonded to cylinder by pressure-sensitive adhesive.

There was some discussion on air travel through the form as source of trouble. This travel is not always predictable.

The process of printing four-color wet gravure was discussed. The four colors are applied in a matter of seconds with no drying between colors. This is sheet fed.

There was considerable discussion on the subject of the amount of ink transfer from letterpress plates to paper at time when best printing conditions are reached. It was definitely stated that, based on a number of tests, approximately 50% of the ink is transferred with each impression.

Mr. Andella's formal talk follows:

R. H. Hurst, *Secretary*

Multicolor Letterpress Printing

Dee James Andella

I feel highly honored in having the privilege of taking part in your cosponsored program of this evening. I am particularly grateful for this opportunity to present a printer's point of view on the subject of improving paper printability through fine coating applications.

I can still recall with pleasure the previous graphic arts meeting I attended here, and the cordial reception I received from the TAPPI members at the Statler Hotel in Boston a few years ago.

When I received Mr. Wilkins' kind invitation to speak before this joint group, the suggested theme "Quality Improvement of Paper and Board Through Coating" rather startled me because I didn't feel that I could add much to the subject of making fine coated papers.

However, by the time official correspondence had completely authorized my taking part in your program, I had managed to twist the words of your theme to read "Improvement of Paper Printability Through Quality Coating."

Yet, even this title didn't seem to ring quite true because I feel that there is a great deal more to paper printability than just fine coating. In fact, as I thought it over, the subject seemed a bit presumptuous on my part to tell you what a printer might demand of paper makers in the coming years.

Facts concerning a multitude of paper developments accomplished during the past 25 years have enabled many a printer or publisher to do a better job, more economically, with increased quantity in a given period of production time.

If we turn back the pages of time to this world of about 25 years ago, we find that the terrific improvements in color photography are forcing a natural interesting appeal in the public's eye. This appreciation of color illustrations by the consumer of printing challenged the advertisers to include more color in their promotional programs. Full-color reproductions of a great variety of products immediately created great buying power, and such appeals brought great increases in sales. Thus it may be noted that low cost and ready availability of color copy, that is, color transparencies, along with the tremendously increased interest of color by these color-conscious buyers of printing, motivated the need for greater color printing production presses.

In the following years, we find that the printer's demands for greater color printing production capacities were met by newly designed machinery and suitable materials to be properly employed thereupon. From single-color process printing, through the stages of two-color work, four-color sheet-fed presses, and finally reaching our present era of the high-speed, multicolor web-fed printing, each new reproduction heights were achieved. All this could not have been possible without the great concentration effort by manufacturers of equipment and material.

Yes, it seems to me that we, the printers, are obligated to all of these manufacturers in the printing industry and its allied trades for helping us meet the demands of our buying public.

Of these many printer's demands, I feel the most important was, and still is, improvement in coated paper printability. With each successive speed increase in newly designed printing presses came new challenges for the coated papers. The printer's demand was coated papers that would permit four films of color inks to be properly "trapped" onto its surface in successively split seconds, then penetrate sufficiently to bind the image and dry reasonably fast, yet retain fairly brilliant body color, and all this with good color register. These and many more paper characteristic demands of the printer were met by the manufacturers of coated paper.

Now, I don't mention these remarks to flatter you. They are statements of fact that prove how printers or publishers look to you for improvements in coated paper printability, just as anxiously as you look to the printing industry for increased sales.

Constantly increasing costs of labor, material, and equipment, plus the ever growing competition from other advertising mediums, are presently showing a strain on the printing industry. The improvement pace of the past 25 years must continue with emphasis on quality, along with the technological successes for increased production quantity—the need for both of these has always been and still is great.

Let us assume that a paper mill is producing a certain tonnage of coated paper by a particular team of people, material, equipment, etc., in a given period of time, and then by some change in this team or method they succeed in doubling the tonnage output of product. This may not necessarily mean that the product of the doubled tonnage is better than, or as good as, the previously manufactured paper, in fact, it may not be quite as good, but the point remains that some definite progress in manufacturing this paper has been made. It is very possible that this new method of production could reduce the cost of this paper. This reduction in cost could make it possible for more people to enjoy its ultimate end result, also another point for progress. However, if it is not an improvement in the actual quality of paper surfaces for printability, then we cannot so designate it.

What I am really trying to explain is the difference between quality and quantity improvements. An improvement that results in quantity can usually be simply noted by figures, whereas an improvement in quality is a rather abstract matter even with conclusions from the best of tests. Quality being defined as a certain degree of perfection as compared with a predetermined standard, it therefore has a variable aspect. The quality of a product may then be judged, realized, or described as either "higher" or "lower" than a specified degree of perfection.

Methods of applying tests to determine whether or not a particular product is within the specified limits of quality variability are not usually absolute measurements. However, for all practical purposes, this production function of inspecting and testing throughout the process of manufacturing certainly does help maintain standards of quality in daily production.

A papermaker passes judgment on his product by certain predetermined standards concerning such visible or tangible qualities as weight, finish, opacity, color, etc. The final and proving test of that paper's printability takes place in some printing process.

At this point, realizing that discussing the problem of quality versus quantity in any manufacturing process is a most difficult task, I decided my remarks should be restricted to the operational phases of multicolor letterpress printing as I know it to be employed in the production of the *National*

Dee James Andella, Illustrations Staff, *National Geographic Magazine*, Washington, D. C.

Geographic Magazine. From these experiences I could then draw my points of discussion related to printability of coated papers.

I propose to present the printer's objective in relation to what is expected of paper, plates, inks, machinery, and the craftsmen' techniques for fine reproduction of color illustrations.

PRINTING PROCESSES

As you may know, full-color reproduction of copy, art drawings, or color transparencies may be printed in large quantities with speed by any one of the three major printing processes: namely, letterpress, offset, or gravure.

All three methods are based on the principle that the design or image must be composed of, or reduced to, a series of dots forming lines that stand apart in various sizes to form tone values from extreme pinpoint highlight dots, through the middle gray tones, onto the dark solid shadow tones. The transfer of inks from these various sized dots onto a paper surface completes the printing impression to reproduce an illustration.

We also know that this paper surface may or may not be coated, depending on the process employed and the nature of subject matter. However, aside from newsprint, some form of coated paper is employed in the printing industry in greater quantities than any other paper. This fact immediately makes coating a very important part of papermaking.

Although the letterpress process is the greatest consumer of coated papers, use of special manufactured coated papers for the offset process has greatly improved quality of color reproductions. Publishers employ all three processes successfully in publications. Each process requires the use of distinctive equipment, material, and techniques which when combined produce an individual character. Furthermore, each process enjoys certain advantages, so that one must evaluate the merits of a particular process with that of another, only in relation to a specified copy or printing requirement. The possible results in reproductions by the three different processes are very broad, but not unlimited. It is very probable that any collection of printer's copy could be reproduced in exactness if each were printed separately by the most suitable method, without regard for quantity, time, and cost, but, unfortunately, color printing is not thus reproduced.

EVALUATION AND ANALYSIS OF PRINTING RESULTS

Ordinarily, publication forms are assembled in large, mixed groupings, all color illustrations being inked en masse, the flow of inks being necessarily set for the best average color requirements of each column on press sheet.

Now let us pause for a moment to analyze the following comparison before we continue our evaluation of printing results.

1. An original art subject may cost hundreds or thousands of dollars, a full-color reproduction of same may cost but a few cents each.
2. It may have taken the artist days or months to complete the drawing, yet the reproduction is made on press in the matter of a few seconds.
3. Whereas the artist may have employed a great variety of color pigments and mixed them in many combinations at will, the printer's reproduction is made with only the three process colors, yellow-red-blue, and black.
4. Whereas the art work or color transparency is accomplished in continuous tone, the printer is restricted to work in halftone.
5. While the artist can splash brilliant colors upon the canvas, the printer must restrict his flow of ink for fear that too much color might cause fill-up of dot values or offset of images.
6. Finally, we note that the original art work is usually accomplished on a very fine paper or canvas cloth, while the reproduction is made on some coated paper.

Thus, it may be noted that the printer, by his limitations in control of equipment, material, and techniques, has greater restrictions forced upon him than did the artist in creating the original copy.

Yet, despite all these problems, amazingly faithful reproductions can be achieved in the various printing processes of today.

The foundation of such successful color reproduction is based on the employment of highly specified quality material to be properly manipulated by skilled men on carefully regulated machinery. This does not necessarily mean that the finest halftone combined with the best ink money can buy will print well on a particularly fine grade of coated paper. Rather, it means that the proper combination of these basic elements be employed. Moreover, each member of your production team must have the will or desire to create such quality printing. Sometimes, even with proper material and top craftsmen, functional failures of equipment prevent the production of quality work. As my college professor would say, "There are too many acts of God and works of the Devil to permit the assurance of a perfect printing."

Yes, the old adage, "A chain is as strong as its weakest link," applies well in the manufacture of fine printing, as it does in papermaking. The relationship of material to machinery and techniques is very critical. The failure of performance in any one of these directly affects the resulting quality of printing.

An examination of the various component parts of printing operations must be analyzed separately, and in relation to their whole, before one can fully understand and appreciate what is involved in the manufacture of quality color printing.

Copy

The first essential requirement for quality printing is good copy. Select and prepare your copy to meet your printing requirements, keeping in mind choice of process, paper, plates, inks, to be used for desired effect.

Black and White

1. Photographs or art work should be about 25% larger in size than the final reproduction.
2. Photographic prints should be made on glossy paper and properly mounted on a cardboard for body strength.
3. Select photographic prints which are in very sharp focus.
4. It is most desirable that the photographic prints contain a contrasting gradation of tone values from deep shadow blacks to extreme white highlight.

Color

Some years ago about 90% of all printer's copy was art work and only about 10% of this was color transparencies. Today, that situation is almost reversed. The buyer of printing today is more color conscious than ever before. The terrific advancements of color photography in the past 15 years have made color copy cheap and readily available for printing reproduction.

1. In selecting color transparencies, avoid those which are too thin or too heavy in color.
2. Above all, be sure that each transparency is perfectly sharp in focus.
3. Practically any color transparency that can be made into a successful color print can be used for printing reproduction.
4. Transparencies can be color-corrected by the Macbeth Chromocritic Machine with additions or subtractions of daylight and artificial lighting. This, plus any other correction from original copy, should be noted to the engraver always before platemaking, not after first proofs are submitted. Give the engraver the finest of copy and you will find that he can very reasonably reproduce the picture on metal.

Photoengraving

The next step in our story of color reproduction is photo-

engraving. Of the two distinctly different methods employed in the making of color engravings, the indirect method is steadily becoming more prominent in usage over the direct method. In fact, some color subjects are most difficult to reproduce with photographic accuracy by depending entirely on hand correction methods. Such copy as oriental rugs, complicated varicolored fabric patterns, multicolored flower garden scenes, or any of a variety of intricate color designs or detail are by far best produced by some indirect or masking method.

In producing color engravings, much time is spent in color correcting because of all the imperfections involved in the various steps of reproduction. For example, sometimes the original transparency is not photographically perfect in color balance so an exact duplication is not desired. The color filters used in making the color separation negatives are not true colors, nor are the photographic steps of exposing, developing, printing, etc., in perfect color control. The greatest part of producing a set of color plates is dependent upon the human element, and we all know that is not too reliable. Finally, all these somewhat natural color failures must be proved on a press with the imperfect colors of process printing inks, not to forget the color variations of so-called white papers that add to our problem.

The direct method of color engraving affords greater manipulations from camera to final etching because of its mechanical masking medium. Also, it helps eliminate much of the guesswork normally made by personnel. Even before the images are engraved upon the metal, the masking method permits the camera department to better see, study, and photographically color correct each color separation to insure greater fidelity. Color can be more skillfully strengthened or weakened by the indirect masking medium whereby such corrections are made on the continuous tone images, rather than on a few small dots of copper. The successful enlargement or reduction of such small halftone dot structure is limited to the ability of the craftsman's hand manipulating certain metallic tools.

To insure quality color printing, let us start by getting a good set of color engravings with proper balance of color values affording a high degree of photographic quality in reproduction.

Of course, a printer is also concerned about the mechanical aspects of color engravings. He requires proper plate depth, or what's more important, clean areas between the dot surfaces or walls of dot structure. Furthermore, he expects the plates to have smooth dot surfaces (not rounded off), no undercutting of dots, and undercolor sufficiently reduced for proper trapping of inks. This takes us to the subject of color proving of engravings.

Color Proving

Color engravings must be made with the ultimate printed result in mind. The engraver should contact the printer to arrange for getting some of the paper and inks for proofing. The two should get together on the matters of type of press to be used in final production, rotation of inks, in line arrangements of color pages, etc., to insure certain similar standards for the job.

The photoengraver's responsibility does not end until the printed result is in the hands of the happy customer. All too often the printed result falls short of the engraver's color proofs in the estimation of the buyer and this creates an undesirable situation for all concerned.

Where plates are concerned, most of the confusion that arises between the engraver and the printer is caused by lack of cooperation to proof the plates in such a manner that the printer can duplicate them with satisfactory results. Usually, the engravings are not mechanically deficient.

What good is a proving press and the proofs it produces, unless they fulfill their value for purpose intended? A good engraver's proof should be a true indication of the final printed result, or what we term a practical match of proofs.

Actually, the important fact about this matter of engraver and printer is to design some system, through experimental efforts, whereby the engraver must do certain predetermined things in his color proving which make it possible for the printer to get a good match on his production press. This experimentation may involve rearrangement of printing impression, make-ready, type of rollers, new formulation of color inks, etc. The cooperation of engraver and printer to standardize proving procedures can help make the necessary correlation for matching color proofs and thereby satisfy everyone.

We have developed such a system for proving our color text pages with our engraver. The identical color pages in line are proved with the same paper and color inks as employed by our printer, with some allowance being made for difference in speed of proving as against that of production press.

I might add that both we and our engravers have identical projection systems designed for viewing color transparencies while color correcting proofs under uniform light conditions.

Electrotypes

With color proofs completely corrected, we now turn to the method of making duplicate plates for the printing production press.

As you may know, due to long press runs, particularly in publication printing, electrotype plates are made from the original color engravings. These are used for printing production, thus safeguarding the originals.

Briefly, by use of heat and pressure, the image of the original is compressed into a sheet of "vinylite" plastic which then becomes the molding medium. After a thin film of silver solution is sprayed over the face of the mold to make the surface electroconductive, a coating of nickel followed by another thin film of copper is deposited onto the plastic mold. We now have what is called a "shell" which is then "backed-up" with molten metal to give the plate body. Upon cooling, the electro is then finished by hand and machine operations of shaving, routing, bevelling, curving, etc. Isn't it amazing that after all this work of forced pressures, heating, cooling, electrolytic depositing, shaving, curving, etc., the electrotyper can produce a set of color plates containing the same color tone values of the original, and all this with good register of each color plate?

Of greater importance to the papermaker and the printer is the surface smoothness of these electrotypes, and this leads me to the next phase in printing production, usually known as plate and press make-ready.

Make-Ready

In order to print clean, sharply registered color tone values, the pressroom must have precision-made electros to insure uniform printing impression. What good is a fine, uniformly coated surface if the surface of the plate to be contacted is not equally true? In other words, if all electros were precision-made, little or no make-ready would be required.

By increasing or diminishing the height or thickness of certain areas of an electro, a printer's make-ready serves to eliminate the inequalities out of the plate surface, in order that the entire plate may receive a more uniform printing impression. In addition, it helps to provide wear protection to the particularly extreme highlight tones.

Correct make-ready procedure requires a complete understanding of the relationship of height of printing plates to press packing. That is, plates must be underlayed with make-ready to conform to a predetermined thickness standard, in relation to the thickness of press packing.

Prior to make-ready, the bearers of both plate and packing cylinders should be checked to insure their making perfect contact with each other. These bearers serve as a guide for

gaging thickness of press plates as well as packing thickness of impression cylinder, in order that the proper printing travel line may be established for a particular printing press.

Theoretically, the printing travel line is an invisible circle that the sheet follows in the act of being printed. This imaginary printing travel line is synchronized to carry the sheet at an established speed through the point of contact between plate and impression cylinders. The plate and impression cylinders each represent circles having a specific circumference ratio to each other when in the act of printing. When the point of printing contact is either above or below the line of travel, one of the circles would then be traveling on a greater or smaller circumference than the other. One surface traveling faster than the other causes friction which not only distorts halftone structure of images, but eventually forces fast, uneven wearing of press plates.

Pre-Make-Ready Plate Treatment

To help overcome the problem of platewear due to long press runs, publication printers usually employ some form of pre-make-ready plate treatment.

Again briefly, a "male" and "female" make-ready is placed on the face and back of an electro in register with the image. Then with application of heat and pressure, the make-ready treatment is compressed into the front and back of the plate. The face make-ready remains in its position until final shave on back of electro is made.

Such make-ready treatment of electros permits a more uniform press run with little, if any, visible plate wear, thereby helping maintain greater separation in detail of color tone values.

With such mechanical accuracy of press cylinder settings, correct underlaying of plates and packing, and effective make-ready applied, printing is then reduced to the simple operation of transferring an ink film from one precision-smooth surface to another, provided, of course, the paper surface is equally smooth.

But before getting on to the act of printing on paper, ink should be our next element for discussion.

INKS

Fundamentally, an ink is composed of two elements, namely a color pigment and a vehicle. The function of the pigment is to provide the necessary body and color strength to the image on paper. The vehicles, varnishes, oils, etc., serve to carry the pigments through the press rollers, onto the printing plates, and eventual transfer to paper surface. They also help bind the pigment to the paper surface, and through their ability to oxidize or harden, they serve to aid in drying of ink.

In any printing ink, the adhesion of the ink for the rollers, plates, and paper must be greater than the cohesional forces present in the ink, otherwise it would not distribute properly.

In printing action, the ink film is ruptured or pulled apart in little mountain ridges which finally break at their narrowest point. Approximately 50% of the ink is then transferred from plate to paper.

The physical properties of an ink which influence its printing characteristics most greatly are its viscosity and thixotropy value factors. Viscosity in common terms may be called the fluidity of an ink, while thixotropy may be thought of as a "brake" on the fluidity of the ink, because this property permits the ink to "gel" in the form of a transferred halftone half on the paper surface.

Printing four colors wet requires color inks that have the proper "tack" balance in color rotation so that when one ink is superimposed over another it must make a satisfactory transfer, instead of trying to lift some of the color off the paper. The first color printed, usually yellow, must be the tackiest, with each succeeding color softer than the preceding one.

PAPER PRINTABILITY

Having now discussed briefly points on copy, plates, inks, press techniques, and equipment, we are ready to start printing in accordance with printing specifications.

The principal commodity in these printing specifications is paper printability. A printer's prime concern is almost entirely with paper printability. He must rely on quality coated paper surfaces that will have the proper affinity to reproduce with exactitude the images engraved on the color plates. However perfectly balanced be the specific standards established for plates, inks, proving, make-ready, equipment regulation, etc., in each instance, they must all be adjusted to conform with the *least changeable* and *most important factor of printing production—printability of paper to be employed.* All other factors involved in printing production are more easily adjusted than are the qualities of paper. Nothing practical can be done to change printability of paper after it is made and coated.

When a job is not printing well, the ink maker is called upon for first consultation and he usually manages to change the working properties of the inks so that the printer may satisfactorily print on that particular load of paper. Sometimes the plates are at fault, and even then the engraver can usually alter the halftone structure to improve the printing. But, if the coated surface of the paper is at fault, there isn't a thing to be done that will change the paper printability.

If we could make a high-speed motion film at the speed of about 3000 frames per second while exploding about 35 flash bulbs, we would probably see in slow motion just what transpires when a halftone dot about the size of a dime comes into contact with a coated paper surface. As I see it, the dot must hit either a fiber, the pigment filler, or perhaps a hole caused by a coating bubble burst.

If the fiber isn't well bound it may be lifted from the paper. Or if the dot hits a highly polished or thick filler section it may not properly transfer its ink, but rather slide it around a bit. Then too, this dot could hit the dull or thin area and become quickly dispersed through the coating and into the body stock to give a flat loss of detail appearance. Of course, should it perchance hit the hole or valley on surface, the result is a very weak dot, if any. When a coated paper surface contains these faults and some others, there is not a thing that can be done to overcome this condition.

For example, when a very fine halftone screen is employed in printing on a hard surface coated paper, the ink cannot sufficiently penetrate the surface. Improper transfer of ink from plate causes excessive ink to accumulate on the dot structure, finally falling into the depths between dot surfaces. These nonprinting areas fill up and actually print, thus resulting in loss of detail and distortion of color tone values.

Advantages of Coating

1. To fill in the inequalities of raw stock surface.
2. Mineral matter of coating permits better transfer and absorption of inks; more easily wetted by oily inks.
3. Uniform porosity of coating surface makes for smoother deposit of inks.
4. Clays of coating give greater brightness to illustrations.

Papermaking, like any other manufacturing process, has its quality limitations. Improvement of one quality characteristic is often accomplished with sacrifice of some other quality factor. Usually, the main reason for quality compromise is competitive costs in production process.

Increased density of base stock by beating affects ink receptivity of coating.

With increase in moisture content of base paper, wax number decreases.

Coating formulations can show increase in the bursting strength test, but decrease in tear and fold tests.

High calendering for smoother finish subdues brightness and reduces opacity.

The brighter the sheet, the less quality in permanency.

In order to effect quality printing, coated paper must be manufactured to meet certain standard specifications as to surface, thickness, resiliency, color, finish, brightness, opacity, permanency, receptivity, moisture content, and other physical property characteristics desired. The printer's commanding requirements of a quality coated paper for high-grade color reproduction may be listed as follows:

Like the first requirement of a truly great artist, coated paper must be made to perform with great uniformity. The *first* requirement is *consistent performance* that will permit the printer to make an economical press run, faithfully reproducing the desired quality and quantity of copy. This requirement is also desired in each of the following characteristics.

The *second* requirement would be *uniformity in paper formation.* Paper is bound to be two-sided because of the filtering action which takes place in its manufacture. Theoretically, more filler is left on top than on the bottom. Likewise, the wire and felt sides affect the wetness of paper stock. Usually, the paper fibers are not evenly distributed. All of these factors affect uniformity in formation.

An "open" or "wild" formation results in spotted variations of thick and thin or hard and soft small areas. It is almost impossible for a printer's make-ready to overcome these paper defects because the thick act as bearers upon contact with plates and therefore reduce printing pressure on the thin spots. In a similar manner, the inks are unevenly transferred from plate because of uneven absorption in paper surface. That is, the soft spots accept more ink than the hard ones. The result is inferior printing with a mottled or "spotty" appearance.

A "closed" or uniform formation of raw paper stock is the start of making quality coated paper.

Third in importance is a coated paper characteristic known as *surface smoothness.* This surface quality is usually the printer's greatest demand. A paper uniformly smooth of surface across the entire web or sheet, and consistently so, greatly aids the reproduction of illustration.

Requirement number *four* is noted to be *ink receptivity* of coated surface. It is the ability of a coated paper to absorb a certain percentage of the transferred inks just enough to bind the pigment into the stock, then "set" fast enough so as not to completely penetrate into paper. Paper surface too absorbent to ink causes loss of brilliant color tone values and distorts sharpness of detail.

Good *surface strength* is the *fifth* requirement of fine coated paper. Especially in multicolor printing, where, roughly, the same area of a paper is contacted four different times by the color plates in the matter of a few split seconds, surface strength or resistance to picking of coating is of great importance. If the first color imprinted, usually yellow, picks or breaks the coating surface, then each succeeding color not only contacts a torn surface, but each impression digs out more paper or coating particles which sometimes remain on the printing plates or travel back through the rollers and dirty the ink fountains.

My *sixth* requirement is listed as *uniform thickness* of paper. Across the sheet, and sheet to sheet, or roll to roll, uniformity of thickness is of utmost importance to fine printing, especially in long press runs at high speeds where, in a few minutes, a weakness in thickness of paper may mean many badly printed copies.

Deficiency in *paper opacity* is considered my *seventh* requirement. Such a lack of opacity is chiefly responsible for what is called "show-through" of printed matter on the reverse side of the sheet. Usually, I am told, this is caused by improper calendering of coating. Paper lacking quality of good opacity causes loss of contrasty detail, particularly distracting in highlight areas, tones down brilliancy of color values reproduced, resulting in a generally dirty appearance of printing.

Coating surface brightness is paper's number *eight* requirement. A brightly reflectant white paper surface is very desirable because it helps give lustrously brilliant tones to color values of reproductions, and also permits brighter highlight values to appear in illustrations.

Paper color takes its place as requirement number *nine.* Color variations of paper have a definite effect on color reproductions by accentuating the "warm" or "cold" tones. Off red, white, or blue paper color tints may add to or detract from printed results by increasing or decreasing contrast.

Number *ten* is the quality of paper known as *resiliency.* Fine quality coated paper must not be calendered beyond the elastic limit of its compressibility. For good printing impression, coated paper should have "cushion" in body so as to be able to spring back when compressed by printing impression.

My *eleventh* requirement for fine paper would be *balanced moisture* content. Paper being hygroscopic makes it susceptible to variations of expansion and contraction by atmospheric changes in temperatures and humidity. When paper is so affected, the pressman has great difficulty in accomplishing accurate presswork. Usually the curl or waves in a paper stock cannot be ironed out by the brush systems on presses, and they result in one of several faults such as "blurring," creasing or wrinkling, running color out of register, and they may even fold over to cause plate batters. Bindery operations, such as folding, stitching, etc., often suffer from brittle paper containing improper moisture content.

My final requirement for quality paper notes that it should contain *a high degree of permanency in color and body stock.* In a publication such as the *National Geographic Magazine,* whose volumes are bound and kept for many years of reference in the member's libraries, paper color and strength must be such that they will not appreciably change physically in a period of many years.

Briefly, I have noted that, with management carefully planning to obtain the proper combination of basic elements necessary for quality printing production, and with plant supervisors technically regulating printing equipment for precision performance, along with the craftsman's skillful manipulation of operational techniques, fine color reproduction can be successfully accomplished. Above all, there must exist within each of these key personnel the will or desire to produce quality printing.

RESEARCH AND DEVELOPMENT

Before closing, I would like to make a few remarks about research developments in the printing and allied industries.

Generally speaking, the printers have not been very wise in their responsibilities for coordinated research efforts to improve methods of printing. For many years, printing research has limped along unmindful of the new theories being developed in various other fields of endeavor, and not suspecting their many possible applications for improvement of methods in reproduction processes.

Since the end of World War II, organized printing research, through Printing Industry of America, has become alive and eager again to study, plan, and coordinate printing research developments to help the printer overcome some of his problems.

At present, in the printing and allied industries, there is a constant search for faster and cheaper methods to reproduce quality printing. Many new inventions have been developed in the past few years, but only a few of them are really ready for commercial use. Nevertheless, the full effects of many new developments are just beginning to be felt.

Photographic Copy

It is generally believed that manufacturers of cameras, films, and accessory photographic equipment and supplies have, through concentrated research efforts, improved their products to such a high degree of perfection in performance

that we can truthfully say that top quality copy is now going into the hands of the plate makers.

Photocomposition

In the past few years, the printing industry has witnessed the development of photocomposing machines which produce justified composition in "galley" form directly on film or photographic paper in one operation. Justifying typewriters have also found their place in the manufacture of printing.

Photoengraving

In the making of process color plates, electronic scanning machines are under development, one of which has been in commercial use for about a year. With further development, this instrument will greatly aid the engraver to achieve a more photographic reproduction of color transparencies or art subjects more quickly and therefore at reduced cost. Newly designed high-speed proof presses now permit the printer to get a better match of color copy.

Electrotypes

Plastic molds, temperature controlled electroplating tanks, and chromium-faced electrotypes are now providing the printer with a better printing plate that will serve longer hours in press runs.

Inks

The ink manufacturers, with the aid of their material suppliers, have kept in stride with other developments of greater press speeds and new paper surfaces by providing inks with quicker drying qualities, nonscratching surfaces, truer color shades for process work, proper "trapping" qualities, and many other features of transfer and printing. The development of gloss inks has greatly aided in giving body color to illustrations printed on coated papers.

Make-ready

It may not be long before the make-ready treatment is successfully placed into the original copper engraving by means of a photographic method, thus eliminating separate treatment of each press plate, and permitting make-ready to be administered in small highlight and shadow areas heretofore impossible.

Coated Papers

I know that the laboratories of the paper mills have been constantly guiding their technical personnel in the improvement of quality printing papers. By discussing paper printability problems with their printers, quality control systems have been designed in the mills to provide improved coated papers with consistent performance. Papermakers have been very cooperative in helping the printer overcome his paper problems. I feel certain that such an understanding can and will continue to achieve even greater accomplishments in papermaking and printing.

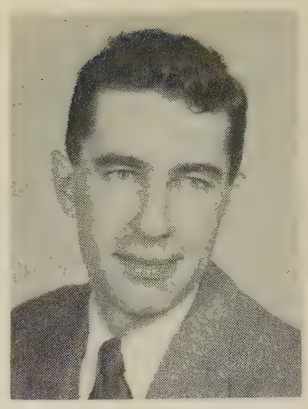
With greater speeds and new methods of multiple-coated papers in sight, the future of high-speed multicolor printing looks very bright, indeed. Let us continue with our constructive thoughts to improve paper printability through fine coating applications.

The customer has become a very critical buyer of color printing. Let us do our part to meet his challenge, as it has been met in the past.

Meeting of May 1, 1952

The Kalamazoo Valley Section met at the Columbia Hotel at 6:30 p.m., Thursday, May 1, 1952. Approximately 60 members and guests attended. John Dam, Jr., Allied Paper Co., Chairman, presided. A. T. Luey, Sutherland Paper Co., arranged for the program.

Mr. Luey introduced A. H. Nadelman, Professor of Pulp and Paper Technology, Western Michigan College, who asked Arne Anderson, recipient of the Second Annual TAPPI Junior Scholarship Award, to present the other 1952 graduates of Western's Pulp and Paper Technology course. Each graduate gave a brief outline of his thesis covering the special project worked on during the year.



A. H. Anderson, Western Michigan College

J. Q. du Pont, E. I. du Pont de Nemours, Inc.

Following are the graduates and titles of projects discussed:

Don C. Burge—Distribution of Particle Sizes in Solids from Deinking Wastes
Theodore R. Kielts—A Proposed Method of Forming a Hexametaphosphate Film on Fourdrinier Wire
Walter J. Redmond—The Effect of Freeness of Unbleached Pulp on the Retention of Certain Wet-Strength Resins
Phillip H. Avery—The Effect of Single and Multistage Bleaching on the Fading Characteristics of Deinked Stock
Yale Brandt—Strength Characteristics of Multi-Ply and Single-Ply Handsheets
Edward G. De Galan—An Instrument Study: The Densichron as a Photoelectric Color-Analyzing Device
Edward J. Horvath—Statistical Analysis of Strength Characteristics of Handsheets
A. H. Anderson—Comparison of Three Stiffness Testers
Harvey Herman—The Influence of Urea and Melamine Resins upon Absorbency and Softness of Paper
William C. Geiger—Comparison of Strengths of Sheets Produced by Standard TAPPI Method and by Means of Noble and Wood Sheet Machine
Roderick A. Perkins—Evaluation of Coated Papers Containing Varying Amounts of Thermoplastic Adhesives
Rudolf Schmut—The Influence of Beating of Pulp upon Fiber Length and Fiber Length Distribution
Daniel E. Bergsma—What Do We Know About the Fundamentals of the Folding Endurance of Paper?
Arthur H. Hupp—The Influence of Electrolytes on Certain Characteristics of Native Corn Starch
Wayne E. Kendrick—The Influence of Electrolytes on Certain Characteristics of Pulp
Richard E. Hathaway—Microscopy of Newly Developed Papermaking Fibers

R. H. Hurst, *Secretary*

Delaware Valley

The regular monthly dinner meeting of the Delaware Valley Section was held at the Engineers Club, Philadelphia, Pa., on April 24. August S. Erspamer, Section Chairman, presided at the meeting.

Joe Paciello gave the report of the Nominating Committee on the results of the balloting for officers for 1952–53. The following were overwhelmingly elected:

Chairman—H. C. Brill, du Pont Co.
1st Vice-Chairman—Frank Lovegren, W. C. Hamilton Co.
2nd Vice-Chairman—Emil Padavic, Container Corp. of America
Treasurer—Ed Molin, Glassine Paper Co.
Secretary—John Steinbinder, Riegel Paper Corp.
Executive Committee—August Erspamer, P. H. Glatfelter Co., and John P. Weidner, Container Corp. of America

Fred Lesser announced that there were six candidates for the Albert Award competition and that presentation of the papers would be made by the authors at the May meeting at which time the winner would be announced. The Albert Award judges are John P. Weidner, Chairman, Walter Morehouse, and Father Malloy.

Mr. Erspamer announced that due to an injury recently sustained, H. H. Hanson, President of W. C. Hamilton & Sons, was unable to present his talk to the Section on "Mill Management." J. Q. du Pont of E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., very graciously accepted to pinch-hit for Mr. Hanson as speaker and presented a talk to the Section entitled, "We're Working While Rome Burns."

Mr. du Pont's talk follows:

"America cannot defend democracy solely by stepping up production. This ideological war can be won by democracy only if its followers are motivated by its spiritual as well as its material values.

"I believe that many more of us American business and professional men must take more time off from our work to think about our specific problem of the slow creeping fire of statism. Then, having thought, and thought deeply, we must devote a generous portion of our waking hours and energy to fighting in the battle for men's minds today.

"Too many people believe that the only necessary defense against communist ideas is a high standard of living in the United States. Coupled with this is the conviction that the only weapon in the communist arsenal aside from the use of brute force is the appeal to the selfish nature of man.

"Communism will breed anywhere where there is a spiritual vacuum; in dire poverty, in middle-class, or in the home and family of a multimillionaire. The pure Marxian commie and the tyrant, the despot, both are wide awake on this point. They fully realize that one unselfish convert is often worth 10,000 needy ones. The real values of such converts is that they 'catch fire' inside. They become crusaders with a mission. They are dedicated to a cause. They want to help others.

"And the path to almost every one of such subverted crusaders' hearts is a hypocritical appeal to the unselfish, the finer side of their make-up.

"The United States with its heritage of freedom tracing to the Constitution and the Bill of Rights, can make such an appeal in all honesty, and to fail to do so is to invite defeat.

"I know the importance of television sets and bathtubs and automobiles. Nonetheless, if we are honest with ourselves, we know that it is not for such things that men will die. But men will die—men are dying today in Korea—for things so deep within them that they cannot even put them in words. And those are the things that will win this fight, if only we can make Americans realize that these deep things are at stake.

"Add them up, and they come down to the concept of human freedom, the freedom of the individual. It is the noblest concept by which any government has ever sought to rule, and ours is almost the only government in the world that gives it even lip service today. That concept of freedom can stir men's minds, can rouse them to topnotch fervor. Let us tell them that the flag has been raised for human freedom, and that if they don't keep it nailed to the mast, the dark ages will sweep over us, too.

"American businessmen must do their part in this struggle, over and above their enormous contributions in the field of production, and they must do it with deeds as well as words.

"I know there was a time when American business was about as young and fresh and as selfish and cruel as a high-school sophomore often is. But I resent being judged today entirely on what we were many years ago. The vast majority of American business has grown up to be a good and valuable citizen. And I can report to you with confidence that most large and small businessmen are out to serve their communities and the nation. The trend is getting stronger every day.

"Indeed, as one whose job it is to travel endlessly and read endlessly, in this present awful battle for men's minds, I'm happy to report that great strides have been and are being made, by small, medium, and large American business in taking up the torch of liberty and freedom against government by edict."

D. H. Newcomb, *Secretary*

Lake States

The fifth meeting of Lake States Section for the 1951–52 season was held in Rhinelander, Wis., during the afternoon and evening of April 8.

The program began at 1 p.m. with a visit to the Rhinelander Paper Co. A large group was interested in this visit, and they were guided through the pulp mill, paper mill, and yeast plant by several well-informed guides.

"Spent Liquor Utilization" was the principal topic of the meeting which was held at Powells'. J. R. Salvesen, Director of Central Research of the Marathon Corp., was the moderator of the following panel:

K. W. Fries, Technical Director, Rhinelander Paper Co., "Why Stream Pollution from Waste Sulphite Liquor?"
N. L. Malcove, Technical Director, Northern Paper Mills, "Present Status of Evaporation and Burning of Sulphite Waste Liquor."
J. M. Holderby, Manager By-products Division, Rhinelander Paper Co., "Torula Yeast from Sulphite Waste Liquor."
W. A. Sherman, Assistant Manager, The Kansas City Star Co., Flambeau Paper Division, "Road Binder Application and Results."
S. D. Wells, Research Associate, The Institute of Paper Chemistry, "The Recovery of Sodium Salts from Spent Liquors in the Neutral Sulphite, Semichemical Neutral Sulphite, Acid Sodium Sulphite, and Kraft Pulping of Wood."

An introduction to the subject was given by Mr. Salvesen, including some background of the work of the Sulphite Pulp Manufacturers' Research League. After welcoming the crowd to Rhinelander on behalf of the paper company, Dr. Fries discussed some of the factors that cause pollution or may be judged as pollutional. The ligneous materials in the liquor are practically harmless and their effect on water is not much different from water obtains in running through a forest that contains decaying wood. The sugars are the offenders in that they consume oxygen in the water. From the standpoint of fish life it is, therefore, a deprivation of oxygen rather than a poisoning that occurs. There is, also, a nuisance problem due to bacteria or algae that live on the sugars, and fibers from a mill may aggravate this by giving mechanical strength to the algae and helping it form solid beds under which gas may form. Aeration can raise the oxygen content if it is too low, but this should not be done too close to the mill as the oxygen content of the river reaches a low point well below the mill. It is not true that sulphite spent materials will "destroy life at the bottom of a stream." A much worse offender in this respect is the silt that runs into the river from cultivated farm lands. The sulphite industry has been conscious of its problem. A good example of progress is the Torula yeast plant at Rhinelander which removes the sugars from the liquor it processes and produces a useful product. Other examples are the shifting from calcium to ammonia-base acid for pulping. Dr. Fries predicted that in the future the emphasis will be on utilization rather than disposal of pulp mill liquors.

Mr. Malcove gave a concise picture of the present status of evaporation and burning of lime-base liquors. The disposal or utilization problem is enormous because the yearly sulphite-pulp capacity on this continent is about 4,000,000 tons. Since there are about 1.2 tons of solids in the liquor per ton of pulp, the total solids are about 5,000,000 tons. Evaporation and burning is a good approach because it creates no market problem. Problems may be divided as follows:

(1) *Collection.* It is important to collect liquor at maximum concentration. It is helpful to leave the padding water out of blowpits. Up to 75% of the liquor can be recovered at digester strength. Countercurrent washing is good but stainless washers are needed.

(2) *Evaporation.* Calcium sulphate in the liquor solids has an inverse solubility, that is, the higher the temperature the lower the solubility, and therefore scale results. The early scale is calcium sulphate with 2 molecules of hydration but further heat develops anhydrous scale which is very troublesome. The shell and tube type of evaporator cannot be used. Two promising types were developed in Sweden. One is the Rosenblad plate type, which forms scale and removes scale by alternate reversal of the steam and liquor flow. Another is the plate Ramen which involves precipitation and crystal formation ahead of the evaporator. It is similar to a multiple-effect evaporator in which liquor enters the fifth effect, then the sixth, and then into a "shock tank" at high temperature to precipitate scale. It then passes to the fourth effect, followed by another shock treatment, then goes to the first, second, and third effects. However, scale sometimes forms on the plates due to poor precipitation. Experiments are being conducted on a Struthers-Wells crystallizer, working on the theory of crystal build-up. So far this has not worked out as well as hoped, partly because the high viscosity of liquor prevents good crystallization. Natural circulation is not effective regardless of the type of evaporators when the concentration is over 60% solids due to the viscosity of the liquor.

(3) *Burning.* The solids have a B.t.u. value of 8000 and 10% ash. Viscosity is greatly affected by temperature. It is advisable not to store concentrated liquor over 52%. Further concentration up to 65% can be attained but should not be stored at this concentration since it is extremely difficult to reheat. Experiments indicated that when ordinary water-cooled boilers are used, coal or oil will be needed as added fuel. The nozzle should be designed to prevent spray from hitting cooler walls. With refractory furnace walls the liquor will burn without other fuel because the refractory aids ignition. In Sweden there is a steel cylinder with refractory lining which partly burns the liquor before it enters a regular boiler. It is possible that a 50-50 concentration material could be burned with such an oven.

(4) *Fly Ash.* This is a problem because over 90% of the ash will leave with the flue gases because it is so light. A mechanical type of collector is satisfactory and should be installed if burning is planned.

Burning can be done by any mill. Also, by concentrating the liquor it is in a transportable form and this is basic to making the many products we expect the liquor to yield in the future.

Mr. Holderby described the yeast process for sulphite liquor used at Rhinelander. The work on this process started in 1943, at which time there was a parallel effort in Germany. The Rhinelander plant has run over 3 years and was recently purchased by the Rhinelander Paper Co. from the Sulphite Manufacturers' Research League. The plant is run basically as a waste treatment unit and not as a yeast plant. It processes about one half of the mill's liquor and achieves about a 70° reduction in B.O.D. Many bacteriological processes could be used to utilize the carbohydrate compounds in waste liquor as a nutrient and thereby consume them, but the yeast-producing processes are preferred because the yeast cells can easily be harvested by separating them through centrifuging. Of the yeast types available, the one called *Torula utilis* is the preferred one since this type can utilize pentoses as well as hexoses. The future is problematical and depends on the market for yeast. Nitrogen, phosphorus, and potassium must be supplied for growth, and power and steam costs are high. The yeast as a by-product must be sold or the operation is not economical. Although the nutritional value of the yeast has not yet been well demonstrated, the potential is great.

Mr. Sherman described the use of sulphite liquor as road binder, and displayed soil before and after hardening with the liquor. The road must be well graded and soft and have several treatments. With rolling or traffic it becomes very hard. The liquor stops dusting and minimizes spring break-up problems. Although the liquor is considered corrosive, it has not made trouble in this respect, and in some cases may even be protective to culverts. Road binder as a use for the liquor may not be an answer to pollution problems because it can only be used for about 4 months of the year. However, these are the hot Summer months when pollutional problems are more severe.

Mr. Wells presented a summary of the work on the recovery of sodium salts from spent pulp mill liquors. This began with a historical sketch of early contributors such as LeBlanc, Dahl, Keebra, United Alkali, and others. The semichemical process using sodium sulphite was outlined. Although the recovery of these liquors should be studied in a pilot plant, prior to this more fundamentals should be learned about methods of analysis, solubilities, melting points, energy factors, and kinetics. The use of sodium sulphite liquors in the kraft recovery system was noted and reference made to patents and work of Drewson, Grunwald, Aries, Pollock, Bradly and McKeefe, Billington, Chidester, Curran, and Richter.

A good discussion and question period followed the talks given by panel members.

After adjournment of the afternoon session, a social hour preceded the dinner. The dinner was attended by about 185, which was a record or near record attendance for such a meeting in this area. Following the dinner, Folke Becker, President, Rhinelander Paper Co., gave a very interesting talk entitled "Impressions and Experiences During My Scandinavian Trip in connection with ECA Mission." Mr. Becker was introduced by J. Richter Salvesen. Chairman Adrain expressed the appreciation of the group for the good work done by Mr. Salvesen, who arranged the fine program, and to Mr. Becker, Dr. Fries, Mr. Reed, and others of the Rhinelander Co. who gave so freely of their time and effort to make the meeting a success.

ROBERT J. SEIDL, *Secretary*

Lake Erie

Fifty members were in attendance at the April 18 meeting held at the Hickory Grill in Cleveland. Three speakers covered practical control measures used by their organizations to better control quality. During the business meeting that preceded the speakers, an election of officers was held and the officers for the ensuing year were elected. Chairman Hasselo announced that advanced notices had been mailed out on the May 23 Folding Carton Forum. Many reservations have already been received and a good turnout is expected.

Dennis Heindel of the Container Corp. of America had for his subject "The Densichron and Other Instruments Used in Color Control."

James Higgins of the Ohio Boxboard Co. described the use of a score bending tester developed at the Ohio Boxboard Co. and also covered the use of the Vallandigham Oil Absorption Meter for the purpose of predicting printability of gloss inks on board.

Robert Overmeyer of Shellmar Products Corp. discussed "Color Control in Gravure Printing of Films and Paper."

The speakers' presentations were well received and a brisk discussion period followed the talks.

R. L. LEWIS, *Publicity Chairman*

The Densichron and Other Instruments Used in Color Control

Dennis Heindel

I WOULD like to discuss with you gentlemen this evening several instruments which are used in the maintenance of uniform color. The two instruments which I want to devote the major portion of the discussion to, are the color booth and the Welch Densichron.

First, however, permit me to mention very briefly the Hunter Color and Color Difference Meter, the Photovolt Brightness Tester, and the General Electric Recording Spectrophotometer.

The Hunter Color and Color Difference Meter is designed and built to match in as a reliable a manner as possible the ability of the average human eye to detect differences in the colors of different objects. While this ability varies considerably with different people and under different lighting conditions, the instrument judges color under very carefully standardized conditions.

The Hunter Color and Color Difference Meter is a photoelectric tristimulus colorimeter designed to give a uniform measure of perceptible differences between colors. The scale readings are so designed that one full scale unit is the equivalent of one commercial shade as determined by the National Bureau of Standards. Thus, with this instrument one can determine whether his colors are one, two, or more shades from the standard. It can also tell how the colors differ; that is, whether they are yellower, bluer, greener, redder, and more, or less, bright than the standard.

The Photovolt Tester. Some plants use the Photovolt Brightness Tester. The photovolt tester will control ink film thickness within commercial tolerances acceptable to the trade. The principal limitation is that of instrument variation and not the method of control.

Perhaps the best instrument for color control is the G.E. Spectrophotometer. However, this instrument is very expensive.

The G.E. Spectrophotometer is an instrument which produces a continuously recorded chart of the quantity of light by a sample as pure light of first, blue, then green, then yellow, then orange, then red, is shined on the sample. This record of the reflecting ability of the sample may be thought of as characteristic of the individual samples, just as fingerprints are characteristic of individual people. Thus, if two samples, when analyzed by the spectrophotometer, produce curves on the graph paper which are identical in all respects, the two samples will match, no matter who judges the match, or what the lighting conditions are.

The color is reflected through a prism. The red, blue, yellow, and the green go to separate prisms. The reflectance goes to a mechanical finger which plots a curve of the color on paper. You then try to get a color to follow that curve.

Curves and interpretive data are turned over to the pressroom supervisor as a check and guide on visual performance. Curves of the freshly printed samples and customer's sample O.K., form a historical background for future runs.

The Color Booth. The color booth is about 10 by 12 feet in area with a 10-foot ceiling. This is large enough to permit examination of a full size two or four-color sheet from all four sides without shifting. The lighting consists of two Macbeth viewing fixtures and four banks of various colors of fluorescent tubes. The lights are hooked up in such a way that any single color or combination of colors can be used at one time.

The Macbeth unit offers a light standard under which color matches are made regardless of day or night conditions. This is very helpful with short Winter days and running of presses at night.

The Macbeth unit which we have in our color booth is $48^1/_8$ by $24^1/_8$ by 13 inches. The Macbeth unit or Examolite produces the closest approach to daylight available commercially. The Examolite offers for the first time a fluorescent "daylight" of three light qualities which may be used for ordinary shade work and flaw examination as well as general examination illumination.

The illumination is produced by three sources of light: (1) three 40-watt (6500 K) daylight fluorescent lamps; (2) two 20-watt blue fluorescent lamps; and (3) six silver bowl incandescent lamps of 50, 100, and 150 watts each. All the light combinations can be easily obtained merely by adjusting switches.

1. One combination consists of three 40-watt "daylight" fluorescent lamps plus two 20-watt blue fluorescent lamps; produces a "blue sky" effect, the intensity of which is 120 foot-candles.
2. The next combination includes all the fluorescent plus six 50-watt incandescent lamps producing an "overcast" sky effect at an intensity of 170 foot-candles.
3. Including the fluorescent lamps mentioned above and by switching the incandescent from 50 watts each to 100 watts each, the color effect "sunlight" and the intensity is 250 foot-candles.

You will note by these energy distribution curves the close reproduction by the Macbeth of both natural daylight and international standard. This quality is essential to accurate color matching where daylight duplication is required. Upon examination of the energy distribution curve of the fluorescent "daylight" it can easily be seen that the energy distribution is dissimilar to that of natural daylight and the Macbeth accurate reproduction of natural daylight.

The fluorescent fixtures are made up of eight four-lamp channels, giving a capacity of thirty-two 40-watt fluorescent lamps. Four-color units are used. Eight blue, eight red, eight gold, and four green lamps are used on their respective circuits. The lumen output of the green fluorescent lamp is much greater than for any of the other colors, so consequently, a spare four-lamp circuit is available for modification to the other circuits. To obtain the proper quality of colored lights, the standard colored fluorescent lamps are covered with theatrical gelatin.

The colored lights are very useful in checking register, in spotting any weakness in the make-ready, in spotting smashes, and in noting of fill-up.

The operation of the color booth, I believe, can best be explained by an example. Let us take for our example the Ritz Cracker Carton which is a four-color job: yellow, brown, blue, red. First, if we wish to check the register around the cracker, we turn on a green light. Any off register is very noticeable. Next, we check the red by turning on a blue light. The red will appear black; thus, any weakness in the make-ready is easily noticeable. Any smashes can be spotted easily. Suppose that we want to check to see if the blue is smearing. If we turn on a red light, the red should not show, theoretically speaking. The blue will appear black. Thus, any smearing is easily spotted because we have black on a white background which gives us an outstanding impression.

The Densichron is built around the "Magnepot" system which works according to the well-known laws of physics governing the activity of electrons in magnetic fields.

A quantity of light strikes part of the cathode of the tube, releasing a proportional number of electrons. These electrons flow to the anode at a steady rate if the light source is constant. The amount of light that is reflected determines the number of electrons which are given off.

Dark areas on the press sheet reflect a minimum amount of light, thus fewer electrons are released causing a low reading on our reflectance meter. Light areas reflect a large amount of light, more electrons being released and as a result, we have a higher reading on our reflectance meter.

When the photographer and plate maker have accurately reproduced on film and plates the separations for color repro-

DENNIS HEINDEL, Container Corp. of America, Cleveland, Ohio.

duction, it remains for the pressroom to retain this accuracy. In so doing the Densichron is used as a tool for the measurement of color as it is affected by ink-film thickness. A check of the press sheet against the O.K. proof will show color fidelity. Likewise, checking the press sheet will reveal improper adjustment of the ink-feed fountains.

We use the Densichron to check for uniform coverage of our ink on the press sheet. However, we do not rely on the Densichron to give us our desired color. We depend on visual means for determining our color. The Densichron merely serves as a guide.

The Densichron is simple to operate and the readings across a sheet of printed stock can be run in a few minutes. It affords a pressman a numerical value to supplement his visual evaluation irrespective of the lighting conditions in the pressroom.

For example, if the color on a press sheet appears to be light at some spots and dark at other spots, we use the Densichron. Most times it validates our visual conception. Say, for instance, the dark area checks 50% reflectance, and the light area checks 55% reflectance. We know then for certain that there is a definite color variance and not merely an illusion.

In operating the machine we have several chips which we use to calibrate our machine. The chips which we use and from which we get satisfactory results are chips "c" and "n." Chip "c" for light colors and "n" for dark colors. The reflectance meter has a scale from 0 to 100. In taking a reading of our sheet we try to calibrate our machine so that we will get a meter reading around 50% reflectance. However, between 35 and 65% is satisfactory.

For example, if we wish to check the yellow on the Cheez-it carton, we would do the following:

Since it is a light color, we would calibrate the Densichron with chip "c." Assume we calibrate the Densichron to 40 on our reflectance meter. Now, we take a reading of our press sheet and find it to be 22 to 24 on our reflectance meter. This low a reading on the meter is not desirable. Therefore, we calibrate our machine. This time let us say to 70. Now, when we take a reading of the press sheet, it should be around 48 to 51. This is what we desire. Our variance can be from 3 to 5% reflectance, depending on the color and, of course, on how the color appears to the eye.

We take a reading across the press sheet. A standard is established; say, for instance, 49 is our standard on the yellow. Our range would be between 47 and 51% reflectance. We can readily pick out our weak spots and our dark spots. The pressman makes the necessary changes and the color throughout the run, is held between the limits.

The Densichron is particularly useful where there are two or more shifts in operation. Colors appear different under normal light than they do under artificial conditions. Therefore, if an instrument, as the Densichron, is used to check uniformity of ink coverage, the color variance between shifts can be reduced to a minimum.

In summary I would like to say the following concerning the Densichron.

1. The instrument is stable and readings are reproducible within reasonable limits over extended periods of time. On the average variation in readings due to instrument variation will be less than 1.0%.

2. The instrument permits fairly rapid and very accurate comparison of a standard and any other similar color. Reading can be made rapidly enough to be of definite value to the pressroom in maintaining color standard.

3. The instrument stability is such that it is possible to set up numerical color standards and work with these values on subsequent printing of the same color.

4. Readings made on printing inks change as the ink dries. For some inks this change is insignificant and readings made within ten minutes after the ink is applied to the sheet will be accurate. There is no set rule to follow in allowing for this variation. Each user must acquire it through experience in measuring the colors he normally uses.

5. And finally, the instrument is a valuable aid in color matching. Its use permits closer matching than is possible with visual inspection by the average observer.

Routine Tests for Scoring and Gloss Ink Printability

James J. Higgins

After being asked to speak at this evening's meeting, I walked into our laboratory to review our routine tests and selected two tests which might be of general interest to the majority of the group. After considering a number of tests, I selected one involved with scoring and another one related to gloss ink printability.

The first, which is a method of evaluating scoring efficiency, is the score bending tester developed at the Ohio Boxboard Co. Before I describe the instrument and explain how we use it for routine quality control, I believe you would be interested in the development of the tester.

Early in 1949, we received a complaint from one of our customers that he was in trouble gluing our gravure printed cartons. It seemed the flaps were bending and bowing during their gluing operation. Upon investigation it was found that some immediate aid could be given by changing some adjustments in the machine. This, however, we realized was a temporary measure and we came back to Rittman searching for an idea and an instrument for evaluating this problem which we thought stemmed from the differences in applying this score. The flap score is rolled into the carton by the gravure press; the score is pressed into the board by the flat bed press.

After searching for a commercial instrument to do the job we required, and finding none, we set about designing a new method of evaluation.

The first attempt of evaluation consisted in backing the flap with a piece of corrugated board and then measuring the force which was necessary to bend the flap. The force was applied perpendicular to the plane of the flap and measured by means of a dynamometer constructed from a number of heavy rubber bands.

This crude method proved satisfactory for the evaluation of a number of samples and we were able to correct the trouble for our customer. However, soon after this episode we received another complaint involving flap score stiffness. It may be easier to understand the problem if I illustrate the trouble with this sample carton. As the cartons are set up on the filling line a device moves one carton into the line from the rack. Here the carton is forced open and it is placed on a jig; the bottom is glued shut while on the jig and then the carton is released and moves along a conveyor. The contents are then inserted and the top closure starts. The two end flaps are turned in and glue applied, the remaining flaps are then prebroken, glued, and turned in by means of plows. Now, on most cartons where the board is stiff enough and the score is satisfactory no trouble is encountered; however, on a light carton the board is not rigid so it is essential that the creasing score is correct or the plow will bend the flap in the middle instead of at the score.

The principles used in the previous investigation were then worked into an instrument which possessed a sample holding clamp and a small dynamometer for measuring the force perpendicular to the flap. Fundamentally the instrument is a device for measuring the maximum force necessary to bend a 6-inch wide piece of carton board 90° at any creasing score.

When we are running orders where flap or body score stiffness has given trouble the cutting press is set up, the packing adjusted, and the tympan female scores cut to obtain the desired stiffness or softness whichever you wish to call it. In

James J. Higgins, Ohio Boxboard Co., Rittman, Ohio.

addition hourly samples are checked to see that the value remains within the control limits. This is necessary since we have noted a gradual increase in stiffness which appears to correspond with the breakdown of the tympan.

The second instrument I wish to discuss with you is the Vancometer. We employ this instrument at the Ohio Boxboard Co. to predict the printability of gloss ink-type boards. Actually we are measuring the oil absorption rate since for the production of a high gloss ink print it is necessary to control the varnish penetration. Some penetration is necessary in order to prevent offset and aid drying.

As many of you know the Vancometer is an instrument which casts a thin film of oil on the surface of the board and then measures the change in reflected light off the film by a photoelectric cell after some period of time. The film is cast by a nip-spreading apparatus consisting of an inclined plane and an 8-pound cylinder. Five drops of oil are applied to the board and the cylinder rolled over the drop spreading the oil into a thin film. The light is projected on the surface at a 22° angle and the reflected light picked up at the same angle.

This instrument is standardized at a reflectance of 100 microamperes by using an opal gloss reflecting surface and adjusting the intensity of the light source with a variable diaphragm.

Now as to the utilization of this instrument for maintaining quality. In view of the numerous variations which exist in the manufacture of board, it was necessary to establish ranges of values for different types of orders, that is, high gloss, medium gloss, and flat ink prints. The quality control department worked out these ranges of values with the carton department and they are as follows:

80–90 microamp. at 60 sec. for high gloss
55–65 microamp. at 20 sec. for medium gloss
below 50 microamp. at 20 sec. for flat

In operation each reel or after a certain time interval (if cutting sheets) samples of board are tested and the material passed or rejected on this basis. The absorbency of the board can be increased or decreased for the most part by changing the concentration or temperature of the calender solution.

Color Control in Gravure Printing

Robert F. Overmeyer

In today's market in which a large portion of sales is a result of impulse buying, product identification and color play a very important and vital part. Many people may not remember the brand name of the product which they purchased and with which they were favorably impressed, but they do remember the design and color of the package in which the product was packed. Thus color and package design assume an eminence as great as product name and trade mark. Furthermore, it is possible that certain deviations from color standards may cause a package to look old or stale when compared with others on the same shelf. This may discourage sales because of either the association with staleness or the thought that others do not like this product as shown by long shelf life. Realizing this, many merchandisers are placing an increasing emphasis on the necessity of their packages meeting stringent color standards. This in turn requires that the package printer use all the resources at his command to meet the color specifications of his customer. New methods of reducing color divergence must be found.

Control of color naturally begins with the composition and purity of the pigments used. The formulation of ink bases must be uniform in composition and the degree of dispersion of pigments constant. Ink formulas should be maintained as consistent as possible. After formulation and delivery to the press, the ink must be thoroughly mixed and constantly agitated to prevent heavy pigments from gravitating to the bottom of the ink reservoir and light pigments from floating.

The actual color match may be obtained by two methods: (1) visual comparison and (2) absolute measurement by use of scientific apparatus. The former is attractive because of the speed with which it may be accomplished and when performed by experts is highly accurate. The latter has the advantage of being independent of human judgment. Therefore, the best procedure for color matching is probably some combination of the two. For example, a color may be matched as close as possible to a working standard by eye and then compared by measurement to the primary standard. After a satisfactory initial match, frequent visual comparisons may be made to the working standard and less frequent measurements may be made to insure that no serious drift is occurring.

Expert color matchers can be obtained only by rigorous training of qualified personnel. Modern scientific apparatus is readily available for absolute color measurement. The Hardy recording spectrophotometer and tristimulus integrator is an example of this apparatus. With this equipment it is possible, in effect, "to draw a picture of color" and from this picture numerically define the color measured. It is frequently possible, by careful study of the color curve to determine the number and character of the pigments employed to obtain a given color.

A valuable aid in visually following the changes of color may be constructed by perodically mounting printed samples on a small diameter tube or rod. A mailing tube about 2 inches in diameter is ideal. If printed on a transparent film the samples must each be placed over a satisfactory, uniform background. The samples should be mounted stepwise, so that $^1/_4$ to $^3/_8$ inch of each succeeding sample is exposed.

While it may seem obvious, regardless of what method of obtaining a color match is used, the need of maintaining a primary standard and supplementary working standards is fundamental. Failure to do this is one of the greatest causes for color deviation. Many pigments, when exposed to light will fade, darken, or otherwise change. Others will be altered by age or exposure to adverse atmospheric conditions only. Hence the need for maintaining a primary standard that will not change. Working standards may be handled by the color matcher with ink-smudged hands, or with hands dirtied by dusty ink kits or drums. Frequent use of the standard may cause it to deteriorate. As mentioned above, exposure to certain atmospheric conditions, or light may cause it to fade or darken. All these possibilities point to the need for assuring the use of a fresh working standard which complies satisfactorily with the primary standard. If colors are matched by visual comparison the maintenance of primary and working standards is a serious and almost insurmountable problem. If colors are measured by instrument, the problem is negligible because when once correctly obtained the maintenance of the standard is only one of filing for ready reference.

Another variable with a universally recognized effect on color is lighting conditions. In order to minimize color divergence because of changes in lighting, it is well to have a booth or room where the illumination is constant and where all color matches are made. When tests are made by instrument, a change in calculations is required for each change of illuminant. The influence of lighting on the color match can be reduced by use of the same pigments in each match of a given color. It is also advantageous to make the match with as few pigments as possible.

Having considered possible variables in the raw materials and in the color matching procedure, the printing process should now be scrutinized. For those not familiar with the gravure process of printing, it may be well to outline briefly and simply the essentials of this process. The printing is done from an etched, copper surfaced cylinder, rotating in an ink tank or fountain. The engraved portion of the cylinder con-

Robert F. Overmeyer, Shellmar Products Corp., Mount Vernon, Ohio.

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sists of the desired design or copy; the balance of the cylinder is smooth and polished. As the cylinder is rotated in the fountain, it picks up ink. The unengraved portion of the cylinder is wiped clean by a doctor blade which contacts the printing cylinder between the ink fountain and the contact point of printing cylinder with the web to be printed. It is at this point that the actual printing is accomplished. A rubber impression roll assures the necessary contact. The printed web then is dried by heat which may be applied by any of several methods.

In this process, there are many sources of color variation—some of them of major importance, others of only minor significance. Such things as depth of etch in the printing cylinder, doctor blade and impression roll adjustment, press speed, ink viscosity, uniformity of overprint, etc., affect the printed color.

Because of variables in the engraving process, the depth of etch in the printing cylinder will be irregular. This, in turn, will cause variation in the quantity of ink deposited on the film, and consequently, color variations. This difficulty is important not only because of the disparity it introduces of itself but also because of the dilemma in which it often places the color matcher. While the contrast within a single repeat is usually unimportant where the final unit (sheet, page, package, etc.) is large compared with the repeat size, it cannot be overlooked where the unit is small compared with the repeat size. Where the number of units is small per repeat, the change is usually so gradual that it is unapparent, but where many units are to be made from a single repeat the difference in color may be pronounced when one unit is compared with another. If the color fails to meet the established tolerances with no variables introduced other than the engraving of the cylinder itself, it is evident that the introduction of further variables can only increase the variation. This diversity may also cause poor color control because of continued rematching by the color matcher. Unless the same areas of two printed sheets are always matched, there may seem to be a need for color adjustment when actually the difference in color is caused by variation in depth of etch from one part of the cylinder to another.

Since the quality of print obtained and the quantity of ink deposited on the web are influenced to a great extent by the viscosity of the ink, the color also is influenced greatly by any variation in this property. Therefore, control of viscosity is of prime importance in the limitation of color variation. Experience indicates that all colors are not equally sensitive to changes in ink viscosities. Pastels are much more sensitive than pure colors. Green and purple, for example, are affected easily. Transparent pigments also are influenced by minor viscosity changes.

Finally, the desired color may be affected by an underprinted or overprinted color. This color, too, is subject to many of the variables mentioned above, and consequently, even though it may not be actually visible in the ultimate design, its influence must be constant. Therefore, to maintain good color control on the desired color, it becomes necessary to apply measures of control to both.

The following should be included in a summary of the factors necessary for good color control in gravure printing:

1. Control of raw materials—pigments, dispersions, and ink formulations.
2. Thorough agitation of printing inks.
3. Maintenance of a primary standard and supplementary working standards.
4. Use of uniform lighting for color matching.
5. Use of the same pigments at all times when matching a given color.
6. Reduction of variation in depth of etch in the printing cylinder.
7. Control of printing ink viscosity.
8. Consideration of effects of overprinting or underprinting.

Standard Terms Used in the Sulphite Pulping Process*

Revision of TAPPI Tentative Standard O 406 p-49

THIS STANDARD IS UNDER THE JURISDICTION OF THE ACID PULPING COMMITTEE

1. *Total Sulphur Dioxide:* Total SO_2 as determined by titration according to TAPPI Standard T 604 m, and expressed as Per Cent Total SO_2.
2. *Free Sulphur Dioxide* (more properly called "available" SO_2): The sum of the actual free SO_2 plus one half of the SO_2 combined as bisulphites as determined by titration according to TAPPI Standard T 604 m, and expressed as Per Cent Free SO_2.
3. *Combined Sulphur Dioxide* (more properly called "nonavailable" SO_2): The SO_2 combined with the base as monosulphite. Determined by difference, subtracting the Free SO_2 from the Total SO_2, and expressed as Per Cent Combined SO_2.
4. *Sulphur Dioxide:* SO_2 gas made by burning sulphur or pyrites with sufficient air to form SO_2.
5. *Bisulphite Liquor Base:* Alkalies or alkaline earths used in the preparation of bisulphite cooking liquors. These may include calcium, magnesium, calcium and magnesium in combination, sodium, and ammonium, used in the form of lime or limestone, dolomitic limestone, magnesium oxide, soda ash, and ammonia, respectively.
6. *System Acid:* Bisulphite liquor prepared by combination of SO_2 and base in the presence of water, with excess SO_2 in solution. Also known as Tower Acid or Raw Acid. In a two-tower absorption system the liquor from the first tower is sometimes called Strong Acid (or Strong Liquor) and that from the second tower Weak Acid (or Weak Liquor).
7. *Storage Acid:* System acid in reserve, for transfer to acid accumulators for fortification by injection of additional SO_2. Also sometimes known as Raw Acid.
8. *Accumulator Acid:* Storage acid held in pressure vessels during fortification by the SO_2 in digester-relief gas or by the addition of liquid SO_2.
9. *Cooking Liquor:* Accumulator acid after fortification is completed and ready for use in the digester cooking operation. Also known as Strong or Finished Acid.
10. *Digester Liquor:* Cooking liquor as it exits in the digester at the various stages during the progress of the cooking operation.
11. *Digester Top Relief:* Gas (or liquor, when the digester is heated by direct steam) withdrawn from the top of the digester during the early stage of the cooking operation and returned to the accumulator (or reclaiming system) to conserve SO_2 and heat.
12. *Digester Side Relief:* Digester liquor withdrawn by side relief from the upper section of the digester in the early stages of digestion and returned to the accumulator or storage to conserve SO_2 and heat.
13. *Digester "On-Side" Test:* Test of the digester liquor for Total, Free, and Combined SO_2 just before the digester is put on side relief.
14. *Digester "Off-Side" Test:* Test of the digester liquor for Total, Free, and Combined SO_2 just after the digester is taken off side relief.
15. *Digester "Blow-Down" Test:* Test of the digester liquor for Total, Free, and Combined SO_2 at the beginning of the pressure-relief period toward the end of the digestion.
16. *Digester "Blow" Test:* Test of the digester liquor for Total, Free, and Combined SO_2 just before the digester is blown.

Note: The determinations in items 13, 14, 15, and 16 are made by the procedures referred to in items 1, 2, and 3.

17. *Spent Sulphite Liquor:* Liquor which is separated from the pulp after the digester is emptied and containing the dissolved constituents of the wood. This is also known as Red Liquor.
18. *Sulphur Consumption:* Pounds of sulphur (from elemental sulphur, pyrites, or SO_2) consumed per ton of air-dry pulp, determined from operating and inventory records.
19. *Limestone, Lime, etc., Consumption:* Pounds of base material consumed per ton of air-dry pulp, determined from operating and inventory records.

ADDITIONAL INFORMATION

This Standard was originally designated as O 406 p. The number was changed in 1952 to O 300 p. Spent Sulphite Liquor (item 17) was formerly termed Sulphite Waste Liquor.

* This recommended practice has been approved as a tentative standard by the Standards Committee. Criticisms are earnestly requested and should be sent to R. G. Macdonald, Secretary, Technical Association of the Pulp and Paper Industry, 122 E. 42nd St., New York 17, N. Y.

ELECTRIC CABLE INVESTIGATION REPORT

A. O. MORTENSON

At the Fifth Engineering Conference in Cincinnati in 1950 the TAPPI Electrical Engineering Committee created a subcommittee and charged it with the responsibility of investigating the application of electrical cable in the pulp and paper industry in an effort to "standardize power cable specifications for all departments in every branch of the pulp and paper industry." Those specifications when written and adopted are to become TAPPI Standards for the use and guidance of all members, associates, and others who may desire to employ them.

Considering the multiplicity of conditions that must be met in the industry by cable insulations and their protective coverings, such confusion exists at present in the electric cable field as to make intelligent determination and selection of what should be used for each service, under each condition, a momentous problem if not an impossibility. The Electrical Engineering Committee strongly felt that much more than slight correction, clarification, and simplification could be brought about in this field, and that, if the problem was properly pursued, it would rebound to the benefit of all concerned—the cable manufacturers as well as the pulp and paper manufacturers. So, pursuant to the committee's decision and instructions we became very actively engaged early last Spring in the task they had allotted to us. A tremendous amount of work in this connection has since been done, and a tremendous amount of information and data have been gathered and tabulated.

FIRST SUBCOMMITTEE MEETING

After some delay, due principally to a misunderstanding, the first subcommittee meeting took place at Cantonment, Fla., May 11, 1951, with five committeemen present, one of whom, by the way, being a technical director, kept the committee properly advised during its deliberations as to the chemicals to be encountered in each department. At that meeting the committee's aim was stated as, "to recommend to our parent organization, TAPPI, specifications from what is in the field today that will serve best in all departments of the industry taking in groundwood, sulphite, sulphate, waste paper, rags, and what have you"—so that later, when one sets out on a plan of improvement—plant expansion, renovation, or new building—the standards set up by TAPPI can be used with assurance that the best the market affords is being specified for every service contemplated.

Generally speaking, only the sulphate branch of the pulp and paper industry was considered that first day, after which a questionnaire was drawn up for submission to the entire industry. To get the feel of what was before us we considered every room and department of a sulphate mill and set off cable and wire types against conditions, chemical and otherwise, encountered in each room or department. Decisions were reached and tentative selections of cable types made, all of which have already been reported in *Tappi*. Also, conclusions were reached regarding cable splicing and terminating, method of making joints, tapping, taping, stress coning, and general procedure in handling and installing electric wires and cables. Even though those conclusions have been printed, it might be advisable to emphasize them again because they mean so much to the life of any cable installation if they are abided by. On all big jobs, whether they are just extensive renovation jobs or complete new construction jobs, the cable manufacturers' materials should be used and his recommendations followed when making up the terminations and joints because no installation is any better than the poorest joint or splice in the system. Close supervision to ensure good workmanship is tremendously important because the best materials are no good if they are not applied right.

A. O. Mortenson, Member TAPPI; Chairman, TAPPI Subcommittee on Cable; Chief Operating Engineer, St. Regis Paper Co., Kraft Paper Div., Cantonment, Fla.

QUESTIONNAIRE

Shortly after adjournment of that first subcommittee meeting, questionnaires went out to 833 pulp and paper mills on the North American Continent and United States' possessions elsewhere. The response was excellent, being well over 30% by now, and the information given was much more than requested in a great many cases. That questionnaire contained three keys—a cable type key, a method of installation key, and a room key—and inquired as to what was best to use (and how) for each of seven different services in every room of the plant. It also looked into the common causes for cable failure and where those failures occurred together with the chemical and other conditions encountered in the various departments. The composition of the various liquors and solutions were also listed. The questionnaire was quite complete, and the response to it was such that a good representative cross section of the industry was covered revealing in no uncertain terms what has been found best, from experience, to use in every room of every branch of the industry.

SECOND SUBCOMMITTEE MEETING—JOINT MEETING WITH IPCEA COMMITTEE

The Insulated Power Cable Engineers Association graciously accepted an invitation to work with us and appointed six very able gentlemen, whose names and affiliations have already appeared in *Tappi*, as a contact committee. So, our second meeting, which was held (also in Cantonment), July 27, was a joint meeting attended by both TAPPI and IPCEA men. At that meeting cable shielding with semiconducting sheaths was delved into rather extensively. The ensuing discussion brought to light the fact that the ignorance of the purpose of such shielding and how such cable should be handled and installed was very general. So much so, in fact, that even though the Underwriters have ruled and the National Electric Code stipulates shielding of cables in conduits for all voltages above 2000 if dampness can occur, the rule is being winked at because of the numerous mishaps (blowups) that have occurred because of improper installation due to ignorance of how it should be done. Much spade work must be done in educating the electrical craft in the technique of handling this type of cable before it can come into general use even though there is a great need for it in all industries, particularly the paper industry where there is so much moisture, dampness, and humidity.

At this second meeting much of what was learned from the questionnaires was presented, tabulated, and discussed.

CABLE TYPE CHOICES

Table I, "Type of Cable Preferred," is a chart compiled from the returns received from the questionnaire we sent out. In compiling these particular figures no attempt has been made to consider anything but each branch of the industry itself and the type of cable used and preferred in each branch. The type of service—whether motor leads, motor controls, or what-have-you—and the department in which used are forgotten for the moment; but, are considered

later. Considering the industry as a whole we find natural rubber braided just edging out natural rubber neoprene sheathed with 23 against 22% and thermal plastic coming in third with 14.6%. I think it is interesting to note just how selective the engineers in the various branches of the industry have been and are. Don't tell me that they have no ideas about what's best to use where. Let's look crosswise at the top row of figures. Sulphate is for natural rubber neoprene sheathed by 35.3%; sulphite 13.6%, little more than a third; groundwood 15.6%, about two-fifths; wastepaper 1.25%, one twenty-eighth approximately; rag 0%; whereas others, all those defying particular classification because they were both sulphite and sulphate, or rag and waste and/or groundwood or some other combination, these favored natural rubber neoprene sheathed to the extent of 24.8%, or it was about five-sevenths as popular here as in the out-and-out sulphate branch. That's showing a marked tendency toward the exercise of preference. Now, let's take a look at what gets top usage in each branch. Sulphate, it is natural rubber neoprene sheathed; sulphite, it is natural rubber braided; groundwood, it is thermal plastic; waste paper, it is natural rubber braided, as is rags and others. Now, let us see what gets next to top usage. Sulphate, it is synthetic rubber neoprene sheathed; sulphite, it is asbestos varnished cambric; groundwood, it is natural rubber neoprene sheathed; wastepaper, thermal plastic; rag, thermal plastic; other, natural rubber neoprene sheathed. The following are in third place with respect to usage. Thermal plastic, sulphate; natural rubber neoprene, sulphite; synthetic rubber neoprene, groundwood; asbestos varnished cambric, wastepaper; varnished cambric braided, rag; thermal plastic, other. More evidence of exercising a preference, I think.

Next we will review Tables II to VII quickly just to show again and emphasize that the electrical men in the paper industry have really shown a high degree of preference. The tables shown cover all the electrical cable services rigidly installed in all departments of the sulphate branch of the industry. For motor leads, natural rubber neoprene, synthetic rubber neoprene, and varnished cambric braided get first, second, and third place, respectively. Table III, motor controls go—one, natural rubber neoprene; two, thermoplastic; three, about an even split between synthetic rubber neoprene and natural rubber braided. Table IV, the choice for lighting is natural rubber neoprene jacket, thermoplastic, and synthetic rubber neoprene in first, second, and third place. Table V, prime feeders—natural rubber neoprene is in first place, synthetic rubber neoprene and varnished cambric braided divide the honors for second place, and aerial self-supporting cable takes third place. Table VI, sub feeders—first place goes to natural rubber neoprene, second to synthetic rubber neoprene, and third place to varnished cambric braided. Table VII, generator leads—using the turbine room as the criterion (generators elsewhere are inconsequential, except perhaps in the machine room) varnished cambric braided gets top honors, natural rubber neoprene comes next with asbestos varnished cambric coming in a strong third. Summing up, natural rubber neoprene shows in first place five times and in second place once, while natural rubber braid shows only in the second place and there but once. Synthetic rubber neoprene shows in second place four times and in third place once. Varnished cambric braided appears once in first place, once in second place, and twice in third place. Thermoplastic appears in second place twice; aerial self-supporting is in third place once, as is asbestos varnished cambric. Throwing all three positions of preference together, first, second and third places—natural rubber neoprene appears six times; natural rubber braided, once; synthetic rubber neoprene, five times; varnished cambric braided, four times; thermoplastic, twice; aerial self-supporting, once; and asbestos varnished cambric, once.

The next three tables are three charts picked at random out of thirty-one. They carry us through three departments of all branches of the industry and take in all types of service. Table XVL, stock preparation room: while this seems to fall into somewhat of a pattern, study will disclose that quite a wide range of difference exists between the branches for the different services. Table XLVI, machine room departments: the same holds for this chart. Study, however, will show that while there is similarity between the two departments, this is somewhat different than the stock preparing departments. Very much dissimilarity could not be expected because there is not too much difference in conditions in the two departments, especially in modern mills. Table XLIX causticizing plant departments: this falls into a very definite pattern, as you can see.

COMMON CAUSES OF CABLE FAILURE AND WHERE THEY OCCUR

Table LXX shows the common causes of cable failure. Generally speaking, deterioration due to age and oxidation accounts for most failures, presence of moisture comes second, and physical damage during installation comes third. However, in the sulphate branch installation damage is in first place and aging third—just reversed. Sulphite steps out of the general pattern for third place and shows improper terminations, stress cones, etc., as it. That same thing, you will notice, in the sulphate branch also, as it runs, as you see, a strong fourth. Table LXXI, predominant location of above failures: cable terminations rank first; splices, second; and cable bends, third. Notice that the general trend holds for the sulphite branch also; one, two, three, cable terminations, splices, and cable bends. But, notice! The order reverses in the sulphate branch—it is up from the bottom rather than down from the top—one, two, three—cable bends, splices, and lastly cable terminations. Just in passing I might say that it strikes me as odd that there would be a direct reversal between those two particular branches of the industry.

INSTALLATION METHODS

Rigid steel galvanized conduit exposed is way out front as the type of installation most preferred. But, that type of installation is now being questioned by eminent authorities who suggest that open work—trays, (open or perforated), open cables on insulators or cleat-supported wiring, or any type of open wiring that would support the cables and protect them from physical, mechanical damage would be better than enclosed installations of any kind that could not be sealed absolutely tight. This is particularly so on nonshielded cables at voltages above 2000 because but little moisture is necessary in such confined installations to permit formation of ozone which results in corona damage to rubber-covered conductors at the higher voltages, especially if conditions are alternately moist and dry. Also other injurious chemicals and fumes can become confined and kept from escaping and thus damage the cable. Furthermore, the entrapped heat in enclosed installations must be compensated for by greater cross section in the conductor, thus increasing costs. Several in the industry have already adopted open wiring for both prime and sub feeders. It warrants looking into for all types of service under certain conditions. Certain industries, the chemical industry for instance, are getting away from conduit and going for exposed wiring in racks and trays. It could be the soundest course from the economic aspect, as well as all others.

JOINT PROBLEM OF CABLE APPLICATION AND ITS INSTALLATION

Through reference to the September, 1951, issue of *Tappi* 34, No. 9: 90A and 92A, it may be learned how others in the pulp and paper industry are meeting the joint problem of

cable application and its installation practicably and pointing the way toward what promises to become future general trends: for instance, aerial self-supporting cable for prime feeders limited in conductor size to 500,000 C.M. and paralleled if necessary to get the required current-carrying capacity; how to use thermoplastic covered wire with good results; preventing failures where vibration is present; getting results with paper insulated lead covered or paper insulated steel armored cable for prime and sub feeders; method of serving portable conveyors through retractable reels; use of bare conductors and steel towers for certain services between buildings; use of copper shield under neoprene jacket for prime feeders and generator leads; experience with sub feeders in floor slab; method of protecting conduits where they come through floor slabs; open wiring for certain departments; how control rooms are pressurized and ventilated; whipping economic, installation, and corrosion problems with Pyrotenax cable. These and several other problems are covered.

SUGGESTIONS FOR BETTERMENT

Also, some suggestions are made. For instance, it is suggested that conduit smaller than 3/4 inch should be barred or outlawed. And, the development of an economical rigid cable support that will withstand the inroads of moisture and corrosive chemicals better than galvanized iron conduit, that often fails completely in as little as 3 years, is indicated. Manufacturers of such merchandise should take notice.

CHEMICALS ENCOUNTERED

In considering the conditions peculiar to each department as had to be done for intelligent selection of cable types, the chemicals encountered in the various departments of the various branches of the industry figured prominently. Our findings in this connection are reported in the September issue of *Tappi* 34, No. 9: 98A and 100A.

SPECIAL RECOGNITION

Unfairness would be exercised if special note was not taken of the great effort put forth on this project by John Eyton, Electrical Engineer for the Abitibi Power and Paper Co., and Chairman of the Electrical Engineering Committee of the Canadian Pulp and Paper Association and I wish to do it before going on to the work that lies ahead. The material he has submitted will be of inestimable value to your committee when it meets jointly with IPCEA next month. He has suggested procedures and through securing the cooperation of the Canadian cable manufacturers he has presented many helpful recommendations. His assistance is appreciated and he and R. H. Andrews, Central District Engineer of the Canada Wire and Cable Co., Ltd., have been invited to sit in with us next month.

WORK AHEAD

Now, very briefly, as to the work that lies ahead—the wealth of recorded data resulting from the questionnaire must be studied in joint committee meeting and specifications written to cover every service in every department in every branch of the industry with a view toward cutting to a practicable minimum the number of cable types and sizes, yet securing the best procurable from the materials available, to meet the needs as stipulated by the recorded data. Those specifications are then to be presented for, we hope, adoption as standards. We expect to have the matter well enough in hand so we can present it at the general meeting in February and so wind up the work of the subcommittee on cable.

Index to Type of Cable Preferred

NRIN	Natural rubber insulation with neoprene covering	AVC	Asbestos varnished cambric
SRIN	Synthetic rubberlike insulation with neoprene covering	VCB	Varnished cambric and braid
NRB	Natural rubber insulation with braid covering	TP	Thermoplastic insulation
SRB	Synthetic rubber insulation with braid covering	WP	Weatherproof
NRL	Natural rubber insulation with lead sheath	AS	Aerial self-supporting
SRL	Synthetic rubber insulation with lead sheath		Copper bus
VCL	Varnished cambric insulation—lead sheath		Other

Room Key

CP	Chip preparation	PBR	Power boiler room
WY	Wood yard	TR	Turbine room
WR	Wood room	SBR	Sulphur burner room
DR	Digester room	AMP	Acid making plant
WHR	Washer room	GR	Grinder room
SCR	Screen room	FR	Filter room
DKR	Decker room	WMR	Wet machine room
SPR	Stock preparation room, beating and mixing, refining and jordaning	RP	Rag preparation (thrashing, sorting, cutting, and dusting)
MR	Machine room	RC	Rag cooking
FR	Finishing room	RW	Rag washing
CR	Coating room	RB	Rag bleaching
CZP	Causticizing plant	HC	Hemp cooking
LR	Lime recovery	HWB	Hemp washing and bleaching
BP	Bleach plant	WPSR	Waste paper storage and sorting room
ER	Evaporator room	WPC&DR	Waste paper cutting and dusting room
RYR	Recovery room	WPCO&DE	Waste paper cooking and deinking room

Table I. Type of Cable Preferred—Across the Board

	Sulphate		*Sulphite*		*Groundwood*		*Waste paper*		*Rags*		*Other*		*Entire industry*	
	%	*No. of answers*	%	*No. of answers*	%	*No. of answers*	%	*No. of answers*	%	*No. of answers*	%	*No. of answers*	%	*No. of answers*
NRIN	35.31	671	13.6	205	15.6	46	1.25	4	0.00	0	24.82	454	22	1380
SRIN	17.24	328	4.85	73	14.7	43	0.00	0	6.46	37	6.95	127	9	608
NRB	8.58	163	29.1	438	0.68	2	34.20	109	45.1	258	27.80	507	23	1477
SRB	0.96	18	1.66	25	4.8	14	9.73	31	3.50	20	2.58	47	2.4	155
NRL	0.69	13	0.86	13	16	47	5.65	18	2.10	12	3.72	68	2.6	171
SRL	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
VCL	5.42	103	10.5	159	1.36	4	5.65	18	8.21	47	1.97	36	5.7	367
AVC	11.32	215	14.3	215	12.7	37	12.20	39	3.85	22	4.93	90	10	618
VCB	4.32	82	7.83	118	1.02	3	7.83	25	13.2	76	6.57	120	6.6	424

Table I. Type of Cable Preferred—Across the Board (*Continued*)

	Sulphate		Sulphite		Groundwood		Waste paper		Rags		Other		Entire industry	
	%	No. of answers	%	No. of answers	%	No. of answers	%	No. of answers	%	No. of answers	%	No. of answers	%	No. of answers
TP	11.90	226	12.9	195	32.4	95	21.62	69	13.8	79	15.22	278	14.6	942
WP	0.15	2	0.80	12	0.34	1	0.00	0	0.00	0	1.10	20	0.5	35
AS	2.85	54	0.06	1	0.00	0	0.00	0	0.00	0	1.00	18	1.1	73
Copper bus	1.26	24	1.19	18	0.34	1	1.87	6	3.67	21	3.28	60	0.6	40
Other			2.39	36	...	...			...	...			1.4	90
													0.6	36
Totals	100.00	1899	100.04	1508	99.94	293	100.00	319	99.89	572	99.94	1825	100.1	6416

Table II. Sulphate—Departmental Cable Types Preferred for Motor Leads in Per Cent of Replies Received

	CP	WY	WR	DR	WHR	SCR	DKR	SPR	MR	FR	CR	CZP	LR	BP	ER	RYR	PBR	TR	GR	FR	WMR
NRIN	27	33	25	27	27	31	27	25	22	36	17	35	20	29	27	22	18	25	100	67	100
SRIN	22	21	21	23	23	22	23	21	18	18	27	23	24	21	23	22	21	21	0	0	0
NRB	9	8	8	9	9	9	9	8	7	7	11	8	12	13	14	11	11	13	0	0	0
SRB	5	4	4	5	5	4	5	4	4	4	0	4	4	4	5	4	4	4	0	0	0
NRL	5	4	4	5	5	4	5	4	4	4	6	4	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0
VCL	5	4	4	5	5	4	5	8	0	4	6	4	12	4	5	7	11	8	0	0	0
AVC	0	0	0	0	0	0	0	0	7	0	0	0	4	0	0	4	4	0	0	0	0
VCB	18	17	17	18	18	17	18	17	26	18	22	15	16	17	18	19	21	21	0	0	0
TP	5	4	12	5	5	4	5	8	4	7	6	4	4	8	5	7	7	4	0	33	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	5	4	4	5	5	4	5	4	4	4	6	4	4	4	5	4	4	4	0	0	0
Totals	101	99	99	102	102	99	102	99	100	102	101	101	100	100	102	100	101	100	100	101	100

Table III. Sulphate—Departmental Cable Types Preferred for Motor Controls in Per Cent of Replies Received

	CP	WY	WR	DR	WHR	SCR	DKR	SPR	MR	FR	CR	CZP	LR	BP	ER	RYR	PBR	TR	GR	FR	WMR
NRIN	47	44	41	50	50	44	44	41	37	50	47	50	41	47	47	41	35	47	100	50	50
SRIN	12	11	12	13	7	13	13	12	11	11	13	11	11	11	12	11	10	12	0	0	0
NRB	12	11	12	13	14	13	13	12	11	11	13	11	11	11	12	11	10	12	0	0	0
SRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	5	6	0	0	0
AVC	0	0	0	0	0	0	0	0	11	0	0	0	5	0	0	5	5	0	0	0	0
VCB	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	5	0	0	0	0
TP	29	33	35	25	29	31	31	35	26	28	27	28	26	32	29	32	30	24	0	50	50
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	100	99	100	101	100	101	101	100	101	100	100	100	99	101	100	100	100	101	100	100	100

Table IV. Sulphate—Departmental Cable Types Preferred for Lighting in Per Cent of Replies Received

	CP	WY	WR	DR	WHR	SCR	DKR	SPR	MR	FR	CR	CZP	LR	BP	ER	RYR	PBR	TR	GR	FR	WMR
NRIN	41	44	32	38	40	36	38	33	30	41	40	39	39	45	33	33	30	37	0	33	33
SRIN	18	17	16	19	20	21	19	17	15	18	20	17	17	17	17	14	15	16	0	0	0
NRB	12	11	11	13	7	7	6	6	5	12	13	11	6	11	11	11	5	11	0	0	0
SRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	0	0	0	0
AVC	0	0	5	6	0	0	6	0	15	0	7	0	11	0	0	14	15	5	0	0	0
VCB	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	5	0	0	0	0
TP	29	28	37	25	33	36	31	44	30	29	20	33	28	28	39	24	25	32	100	67	67
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	100	100	101	100	100	100	100	100	100	100	100	100	101	101	100	101	100	101	100	100	100

Table V. Sulphate—Departmental Cable Types Preferred for Prime Feeders in Per Cent of Replies Received

	CP	WY	WR	DR	WHR	SCR	DKR	SPR	MR	FR	CR	CZP	LR	BP	ER	RYR	PBR	TR	GR	FR	WMR
NRIN	29	27	30	26	26	24	32	31	23	29	28	27	23	30	26	23	18	25	0	0	25
SRIN	17	18	20	21	21	19	21	21	18	19	22	23	23	20	16	23	23	20	0	0	0
NRB	4	5	5	5	5	5	5	5	5	10	6	5	5	5	5	5	5	5	0	0	0
SRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	17	9	10	11	11	10	11	5	14	14	11	14	14	15	16	14	14	15	0	50	50
AVC	4	5	5	5	5	5	5	5	9	5	6	5	9	5	5	9	9	5	0	0	0
VCB	21	18	20	21	21	19	21	21	23	14	22	18	18	20	21	18	23	20	0	0	0
TP	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WP	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	8	9	10	11	11	10	5	11	9	10	6	9	9	5	11	9	9	10	100	50	25
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	100	101	100	100	100	102	100	99	101	101	101	100	101	100	100	101	101	100	100	100	100

Table VI. Sulphate—Departmental Cable Types Preferred for Sub Feeders in Per Cent of Replies Received

	CP	WY	WR	DR	WHR	SCR	DKR	SPR	MR	FR	CR	CZP	LR	BP	ER	RYR	PBR	TR	GR	FR	WMR
NRIN	39	41	39	38	38	38	47	39	32	41	40	39	28	36	33	30	21	35	0	0	33
SRIN	17	18	17	19	19	19	20	17	21	18	20	22	22	21	20	20	21	18	0	0	0
NRB	11	12	11	13	13	13	13	11	11	12	13	11	11	14	13	10	11	12	0	0	0
SRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	6	6	6	6	6	6	0	6	5	6	7	6	6	7	7	5	5	6	0	0	0
AVC	6	6	11	6	6	6	7	11	11	6	7	6	11	7	7	15	16	6	0	50	0
VCB	17	12	11	13	13	13	13	11	16	12	13	11	11	14	13	10	16	12	0	0	33
TP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	6	6	6	6	6	6	0	6	5	6	0	6	6	0	7	5	5	6	100	50	33
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	6	0	0	0
Totals	102	101	101	101	101	101	100	101	101	101	100	101	101	99	100	100	100	101	100	100	99

Table VII. Sulphate—Departmental Cable Types Preferred for Generator Leads in Per Cent of Replies Received

	CP	WY	WR	DR	WHR	SCR	DKR	SPR	MR	FR	CR	CZP	LR	BP	ER	RYR	PBR	TR[a]	GR	FR	WMR
NRIN	67	100	100	100	100	100	100	75	29	75	100	100	100	100	75	100	50	25	0	0	0
SRIN	0	0	0	0	0	0	0	0	6	0	0	0	0	0	25	0	0	6	0	0	0
NRB	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	6	0	0	0
SRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	6	0	0	0
AVC	0	0	0	0	0	0	0	25	18	0	0	0	0	0	0	0	0	19	0	0	0
VCB	33	0	0	0	0	0	0	0	35	25	0	0	0	0	0	0	50	31	0	0	0
TP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99	0	0	0

[a] Using the turbine room as the criterion the above is it.

Table VIII. Sulphite—Departmental Cable Types Preferred for Motor Leads in Per Cent of Replies Received

	CP	WY	WR	DR	WHR	SCR	DKR	SPR	MR	FR	CR	CZP	LR	BP	ER	PBR	TR	SBR	AMP	GR	FR	WMR
NRIN	9	19	9	9	33	9	14	11	13	14	17	0	0	7	0	9	9	5	8	16	25	11
SRIN	5	5	4	5	0	5	7	0	5	7	0	0	0	7	0	5	9	5	4	0	13	0
NRB	29	19	34	32	33	33	29	37	31	29	33	50	100	29	0	23	27	32	29	37	37	32
SRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	9	5	4	5	0	0
NRL	5	9	4	5	0	5	7	5	5	0	0	0	0	0	0	0	0	0	0	0	0	5
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	5	5	9	5	0	5	7	5	5	0	17	0	0	7	0	5	9	5	4	5	0	5
AVC	5	5	4	5	0	5	7	5	5	0	17	0	0	7	0	18	9	16	8	5	0	5
VCB	19	14	17	14	0	19	7	21	18	7	17	50	0	21	0	18	18	11	17	16	12	21
TP	19	19	13	23	17	14	14	11	14	36	0	0	0	14	0	14	0	16	21	11	0	16
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	5	5	4	5	17	5	7	5	4	7	0	0	0	7	100	5	9	5	4	5	13	5
Totals	101	100	98	103	100	100	99	100	100	100	101	100	100	99	100	102	99	100	99	100	100	100

Table IX. Sulphite—Departmental Cable Types Preferred for Motor Controls in Per Cent of Replies Received

	CP	WY	WR	DR	WHR	SCR	DKR	SPR	MR	FR	CR	CZP	LR	BP	ER	PBR	TR	SBR	AMP	GR	FR	WMR
NRIN	13	20	11	11	33	12	17	13	18	17	17	0	0	10	0	10	12	7	11	21	28	13
SRIN	6	7	5	6	0	6	8	0	6	8	0	0	0	10	0	5	12	7	5	0	0	0
NRB	31	20	33	33	33	35	25	40	24	25	33	0	100	20	0	25	25	20	21	29	43	27
SRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	6	7	6	6	0	6	8	7	6	0	17	0	0	10	0	5	13	7	6	7	0	7
AVC	6	7	5	6	0	6	8	7	6	0	17	0	0	10	0	20	13	20	11	7	0	7
VCB	13	13	17	11	0	12	8	13	12	0	17	100	0	20	0	15	12	7	11	7	14	13
TP	19	20	17	22	17	18	17	13	24	42	0	0	0	20	0	15	0	27	31	21	0	20
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	6	7	6	6	17	6	8	7	6	8	0	0	0	0	100	5	13	7	5	7	14	7
Totals	100	101	100	101	100	101	99	100	102	100	101	100	100	100	100	100	100	102	101	99	99	110

Table X. Sulphite—Departmental Cable Types Preferred for Lighting in Per Cent of Replies Received

	CP	WY	WR	DR	WHR	SCR	DKR	SPR	MR	FR	CR	CZP	LR	BP	ER	PBR	TR	SBR	AMP	GR	FR	WMR
NRIN	11	15	10	9	33	10	13	12	10	15	17	0	0	18	0	9	9	6	9	15	12	13
SRIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	5	8	13	7
NRB	47	40	50	48	50	50	53	53	42	54	49	0	100	18	0	41	55	41	33	38	37	40
SRB	5	5	5	5	0	5	7	0	5	8	0	0	0	9	0	5	9	6	5	0	13	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AVC	5	5	5	5	0	5	7	6	5	0	17	0	0	9	0	14	9	12	10	8	0	7
VCB	5	5	5	5	0	5	0	6	5	0	0	100	0	9	0	9	0	0	9	0	12	7
TP	26	25	25	29	17	25	20	24	32	23	17	0	0	36	0	23	18	29	33	31	13	27
WP	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	99	100	100	101	100	100	100	101	99	100	100	100	100	99	0	101	100	100	100	100	100	101

Table XI. Sulphite—Departmental Cable Types Preferred for Prime Feeders in Per Cent of Replies Received

	CP	WY	WR	DR	WHR	SCR	DKR	SPR	MR	FR	CR	CZP	LR	BP	ER	PBR	TR	SBR	AMP	GR	FR	WMR
NRIN	13	13	12	13	25	13	8	13	12	17	17	0	0	20	0	11	9	14	13	15	14	14
SRIN	7	7	6	7	0	7	8	0	6	8	0	0	0	10	0	5	9	7	7	0	14	0
NRB	20	20	19	27	0	20	17	20	19	25	17	0	0	20	0	16	18	21	20	15	14	21
SRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	27	20	25	20	25	27	33	27	25	17	17	0	0	20	0	21	36	29	27	38	29	29
AVC	7	7	6	7	0	7	8	7	6	0	17	0	0	20	0	21	9	7	7	8	0	7
VCB	20	27	19	20	25	20	17	27	25	8	33	100	0	10	0	21	19	14	20	15	29	21
TP	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	0
WP	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	7	7	6	7	25	7	8	7	7	8	0	0	0	0	0	5	0	0	7	8	0	7
Totals	101	101	99	101	100	101	99	101	100	100	101	100	0	100	0	100	100	99	101	99	100	99

Table XII. Sulphite—Departmental Cable Types Preferred for Sub Feeders in Per Cent of Replies Received

	CP	WY	WR	DR	WHR	SCR	DKR	SPR	MR	FR	CR	CZP	LR	BP	ER	PBR	TR	SBR	AMP	GR	FR	WMR
NRIN	7	7	6	7	25	7	8	7	6	10	14	0	0	8	0	5	10	7	6	8	14	8
SRIN	7	7	6	7	0	7	8	0	6	10	0	0	0	8	0	6	10	7	6	0	14	0
NRB	29	29	31	27	0	27	25	33	31	30	29	0	0	25	0	28	20	27	22	25	14	31
SRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	21	21	19	20	25	20	25	20	19	20	14	0	0	17	0	17	30	20	17	25	29	23
AVC	7	7	13	13	25	27	9	13	12	0	15	50	100	17	0	17	10	13	17	8	0	8
VCB	29	29	25	27	25	13	25	27	25	20	29	50	0	17	0	28	20	20	22	25	29	23
TP	0	0	0	0	0	0	0	0	0	10	0	0	0	8	0	0	0	7	6	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	9	0	8
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	100	100	100	101	100	101	100	100	99	100	101	100	100	100	0	101	100	101	102	100	100	101

Table XIII. Sulphite—Departmental Cable Types Preferred for Generator Leads in Per Cent of Replies Received

	CP	WY	WR	DR	WHR	SCR	DKR	SPR	MR	FR	CR	CZP	LR	BP	ER	PBR	TR	SBR	AMP	GR	FR	WMR
NRIN	100	100	100	100	100	100	100	100	18	0	100	0	0	100	0	100	14	100	100	100	100	100
SRIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0
NRB	0	0	0	0	0	0	0	0	36	0	0	0	0	0	0	0	14	0	0	0	0	0
SRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	0	29	0	0	0	0	0
AVC	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	7	0	0	0	0	0
VCB	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	7	0	0	0	0	0
TP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	15	0	0	0	0	0
Totals	100	100	100	100	100	100	100	100	100	0	100	0	0	100	0	100	100	100	100	100	100	100

Note: Only turbine room and machine room considered in considering the relative importance of the various types.

Table XIV. Groundwood—Departmental Cable Types Preferred for Motor Leads in Per Cent of Replies Received

	WY	WR	SCR	DKR	SPR	MR	FR	CR	PBR	TR	GR	FR	WMR	WPSR	WPC-DR	WPCO-DE
NRIN	0	20	0	0	0	13	17	0	17	0	14	0	50	33	0	0
SRIN	25	0	20	14	14	13	17	33	17	17	14	0	0	0	0	0
NRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRB	0	20	20	14	14	13	16	0	17	17	14	0	0	33	50	50
NRL	25	20	0	29	29	24	0	0	0	0	14	100	50	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AVC	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0
VCB	25	20	40	29	29	24	33	33	17	50	29	0	0	34	50	50
TP	25	20	20	14	14	13	17	34	16	16	15	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Table XV. Groundwood—Departmental Cable Types Preferred for Motor Control in Per Cent of Replies Received

	WY	WR	SCR	DKR	SPR	MR	FR	CR	PBR	TR	GR	FR	WMR	WPSR	WPC-DR	WPCO-DE
NRIN	25	0	0	0	25	20	40	33	33	0	17	0	0	50	0	0
SRIN	25	0	34	34	25	20	20	33	17	25	17	0	0	0	0	0
NRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	25	50	0	0	0	0	0	0	0	0	16	100	50	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AVC	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0
VCB	0	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0
TP	25	50	66	66	50	60	40	34	34	50	50	0	50	50	100	100
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Table XVI. Groundwood—Departmental Cable Types Preferred for Lighting in Per Cent of Replies Received

	WY	WR	SCR	DKR	SPR	MR	FR	CR	PBR	TR	GR	FR	WMR	WPSR	WPC-DR	WPCO-DE
NRIN	33	0	0	0	25	20	50	50	50	0	20	0	0	50	0	0
SRIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRB	0	0	0	0	0	0	0	0	0	0	20	0	50	0	0	0
SRB	0	33	0	0	0	20	0	0	0	0	0	0	0	0	0	0
NRL	0	33	0	33	25	20	0	0	0	0	20	100	50	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AVC	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0
VCB	0	0	0	0	0	0	0	0	0	33	0	0	0	0	0	0
TP	33	33	100	67	50	40	50	50	25	67	40	0	0	50	100	100
WP	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	99	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Table XVII. Groundwood—Departmental Cable Types Preferred for Prime Feeders in Per Cent of Replies Received

	WY	WR	SCR	DKR	SPR	MR	FR	CR	PBR	TR	GR	FR	WMR	WPSR	WPC-DR	WPCO-DE
NRIN	0	33	0	0	0	20	25	0	40	0	25	0	50	50	0	0
SRIN	50	0	50	33	25	20	25	50	20	33	25	0	0	0	0	0
NRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	50	33	0	33	25	20	0	0	0	0	25	100	50	0	0	0
SRL	0	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	25	0	0	0	0	33	0	0	0	0	0	0
AVC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCB	0	0	0	0	0	20	25	50	20	0	0	0	0	0	0	0
TP	0	0	50	33	25	20	25	0	20	33	25	0	0	50	100	100
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	100	99	100	99	100	100	100	100	100	99	100	100	100	100	100	100

Table XVIII. Groundwood—Departmental Cable Types Preferred for Sub Feeders in Per Cent of Replies Received

	WY	WR	SCR	DKR	SPR	MR	FR	CR	PBR	TR	GR	FR	WMR	WPSR	WPC-DR	WPCO-DE
NRIN	0	33	0	0	0	20	25	0	40	0	25	0	50	50	0	0
SRIN	50	0	50	33	25	20	25	50	20	33	25	0	0	0	0	0
NRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	50	33	0	33	25	20	0	0	0	0	25	100	50	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	0	33	0	0	0	0	0	0
AVC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCB	0	0	0	0	25	20	25	50	20	0	0	0	0	0	0	0
TP	0	33	50	33	25	20	25	0	20	33	25	0	0	50	100	100
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	100	99	100	99	100	100	100	100	100	99	100	100	100	100	100	100

Table XIX. Groundwood—Departmental Cable Types Preferred for Generator Leads in Per Cent of Replies Received

	WY	WR	SCR	DKR	SPR	MR	FR	CR	PBR	TR[a]	GR	FR	WMR	WPSR	WPC-DR	WPCO-DE
NRIN	0	0	0	0	0	0	100	0	100	0	0	0	0	100	0	0
SRIN	0	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0
NRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
NRL	100	100	0	100	100	100	0	0	0	0	50	100	100	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0
AVC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VBC	0	0	0	0	0	0	0	0	0	50	50	0	0	0	0	0
TP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	100	100	0	100	100	100	100	0	100	100	100	100	100	100	0	0

[a] Only turbine room considered in considering the importance of cable types.

Table XX. Waste Paper—Departmental Cable Types Preferred for Motor Leads in Per Cent of Replies Received

	SCR	SPR	MR	FR	CR	PBR	TR	GR	FR	WMR	WPSR	WPC-DR	WPCO-DE
NRIN	0	0	0	0	0	0	0	100	0	0	0	0	0
SRIN	0	0	0	0	0	0	0	0	0	0	0	0	0
NRB	0	38	29	29	0	13	17	0	0	0	25	100	100
SRB	0	12	14	14	33	13	17	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	0	0	0	0	0
AVC	25	0	0	0	0	38	17	0	0	0	0	0	0
VCB	50	38	43	43	33	38	50	0	67	0	50	0	0
TP	25	12	14	14	33	0	0	0	33	100	25	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	100	100	100	100	99	102	101	100	100	100	100	100	100

Table XXI. Waste Paper—Departmental Cable Types Preferred for Motor Control in Per Cent of Replies Received

	SCR	SPR	MR	FR	CR	PBR	TR	GR	FR	WMR	WPSR	WPC-DR	WPCO-DE
NRIN	0	0	0	0	0	0	0	100	0	0	0	0	0
SRIN	0	0	0	0	0	0	0	0	0	0	0	0	0
NRB	0	45	38	38	25	22	29	0	0	0	25	100	100
SRB	0	11	13	13	25	11	14	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	0	0	0	0	0
AVC	25	0	0	0	0	33	14	0	0	0	0	0	0
VCB	0	0	0	0	0	0	0	0	0	0	0	0	0
TP	75	45	50	50	50	33	44	0	100	100	75	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	100	101	101	101	100	99	101	100	100	100	100	100	100

Table XXII. Waste Paper—Departmental Cable Types Preferred for Lighting in Per Cent of Replies Received

	SCR	SPR	MR	FR	CR	PBR	TR	GR	FR	WMR	WPSR	WPC-DR	WPCO-DE
NRIN	0	0	0	0	0	0	0	0	0	0	0	0	0
SRIN	0	0	0	0	0	0	0	0	0	0	0	0	0
NRB	0	45	45	38	25	22	29	0	0	0	25	100	100
SRB	0	11	11	13	25	11	14	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	0	0	0	0	0
AVC	25	0	0	0	0	33	14	0	0	0	0	0	0
VCB	0	0	0	0	0	0	0	0	0	0	0	0	0
TP	75	45	45	50	50	33	43	0	100	100	75	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	100	101	101	101	100	99	100	0	100	100	100	100	100

Table XXIII. Waste Paper—Departmental Cable Types Preferred for Prime Feeders in Per Cent of Replies Received

	SCR	SPR	MR	FR	CR	PBR	TR	GR	FR	WMR	WPSR	WPC-DR	WPCO-DE
NRIN	0	0	0	0	0	0	0	0	0	50	0	0	0
SRIN	0	0	0	0	0	0	0	0	0	0	0	0	0
NRB	100	38	33	33	17	22	25	0	100	50	67	0	0
SRB	0	13	11	11	17	11	13	0	0	0	0	0	0
NRL	0	13	11	11	17	11	13	0	0	0	17	50	50
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	13	11	11	17	11	13	0	0	0	17	50	50
AVC	0	0	0	0	0	22	13	100	0	0	0	0	0
VCB	0	13	22	22	17	11	13	0	0	0	0	0	0
TP	0	0	0	0	0	0	0	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	1	13	11	11	17	11	13	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	101	103	99	99	102	99	103	100	100	100	101	100	100

Table XXIV. Waste Paper—Departmental Cable Types Preferred for Sub Feeders in Per Cent of Replies Received

	SCR	SPR	MR	FR	CR	PBR	TR	GR	FR	WMR	WPSR	WPC-DR	WPCO-DE
NRIN	0	0	0	0	0	0	0	0	0	50	0	0	0
SRIN	0	0	0	0	0	0	0	0	0	0	0	0	0
NRB	100	43	38	38	20	25	29	0	100	50	67	0	0
SRB	0	14	13	13	20	13	14	0	0	0	0	0	0
NRL	0	14	13	13	20	13	14	0	0	0	17	50	50
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	14	13	13	20	13	14	0	0	0	17	50	50
AVC	0	0	0	0	0	25	14	100	0	0	0	0	0
VCB	0	14	25	25	20	13	14	0	0	0	0	0	0
TP	0	0	0	0	0	0	0	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	100	99	100	100	100	102	99	100	100	100	101	100	100

Table XXV. Waste Paper—Departmental Cable Types Preferred for Generator Leads in Per Cent of Replies Received

	SCR	SPR	MR	FR	CR	PBR	TR	GR	FR	WMR	WPSR	WPC-DR	WPCO-DE
NRIN	0	0	0	0	0	0	0	0	0	0	0	0	0
SRIN	0	0	0	0	0	0	0	0	0	0	0	0	0
NRB	0	0	0	0	0	0	50	0	0	0	0	0	0
SRB	0	0	0	0	0	0	17	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	0	0	0	0	0
AVC	0	0	0	0	0	0	33	0	0	0	0	0	0
VCB	0	0	0	0	0	0	0	0	0	0	0	0	0
TP	0	0	0	0	0	0	0	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	0	0	0	0	0	0	100	0	0	0	0	0	0

Table XXVI. Rag—Departmental Cable Types Preferred for Motor Leads in Per Cent of Replies Received

	CP	WY	WR	SCR	DKR	SPR	MR	FR	CR	BP	PBR	TR	GR	FR	WMR	RP	RC	RW	RB	HC	HWB	WPSR	WPC-DR	WPCO-DE
NRIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRB	50	50	50	100	100	44	40	44	33	20	36	50	50	60	40	40	43	60	60	0	0	33	50	50
SRB	0	0	0	0	0	0	10	11	33	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	11	10	11	0	20	9	0	0	0	0	10	14	0	0	0	0	17	0	0
AVC	0	0	0	0	0	11	10	11	0	40	36	33	0	40	20	20	14	20	20	0	0	0	0	0
VCB	50	50	50	0	0	22	20	11	0	20	18	17	50	0	20	20	14	0	0	0	0	33	0	0
TP	0	0	0	0	0	11	10	11	33	0	0	0	0	0	20	0	14	20	20	0	100	17	50	50
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	100	100	100	100	100	99	100	99	99	100	99	100	100	100	100	100	99	100	100	0	100	100	100	100

Table XXVII. Rag—Departmental Cable Types Preferred for Motor Control in Per Cent of Replies Received

	CP	WY	WR	SCR	DKR	SPR	MR	FR	CR	BP	PBR	TR	GR	FR	WMR	RP	RC	RW	RB	HC	HWB	WPSR	WPC-DR	WPCO-DE
NRIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRIN	100	100	100	0	0	14	13	0	0	0	11	17	100	0	25	13	0	0	0	0	0	25	0	0
NRB	0	0	0	100	100	57	50	57	33	50	44	50	0	60	25	50	67	60	60	100	0	50	50	50
SRB	0	0	0	0	0	0	13	14	33	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AVC	0	0	0	0	0	14	13	14	0	50	33	33	0	40	25	25	17	20	20	0	0	0	0	0
VCB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TP	0	0	0	0	0	14	13	14	33	0	11	0	0	0	25	0	17	20	20	0	100	25	50	50
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	100	100	100	100	100	99	102	99	99	100	99	100	100	100	100	101	101	100	100	100	100	100	100	100

Table XXVIII. Rag—Departmental Cable Types Preferred for Lighting in Per Cent of Replies Received

	CP	WY	WR	SCR	DKR	SPR	MR	FR	CR	BP	PBR	TR	GR	FR	WMR	RP	RC	RW	RB	HC	HWB	WPSR	WPC-DR	WPCO-DE
NRIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRIN	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRB	100	100	100	100	100	57	75	72	67	60	63	50	100	60	50	63	57	50	50	100	100	75	50	50
SRB	0	0	0	0	0	0	13	14	33	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AVC	0	0	0	0	0	14	0	0	0	20	25	50	0	20	25	13	0	0	0	0	0	0	0	0
VCB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TP	0	0	0	0	0	14	13	14	0	20	13	0	0	20	25	13	43	50	50	0	0	25	50	50
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	100	100	100	100	100	99	99	100	100	100	101	100	100	100	100	102	100	100	100	100	100	100	100	100

Table XXIX. Rag—Departmental Cable Types Preferred for Prime Feeders in Per Cent of Replies Received

	CP	WY	WR	SCR	DKR	SPR	MR	FR	CR	BP	PBR	TR	GR	FR	WMR	RP	RC	RW	RB	HC	HWB	WPSR	WPC-DR	WPCO-DE
NRIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRIN	50	50	50	0	0	11	10	0	0	0	10	17	50	0	25	11	0	0	0	0	0	20	0	0
NRB	0	0	0	100	100	33	30	43	50	50	30	33	0	50	25	33	50	50	60	0	0	40	100	50
SRB	0	0	0	0	0	0	10	14	50	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	50	50	50	0	0	33	30	14	0	25	30	0	50	25	50	22	17	25	20	0	0	20	0	0
AVC	0	0	0	0	0	0	0	0	0	0	10	17	0	0	0	0	0	0	0	0	0	0	0	0

VCB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TP	0	0	0	0	0	11	10	14	0	25	10	17	0	0	0	11	17	0	0	0	0	20	0	50
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	11	10	14	0	0	10	17	0	25	0	11	17	25	20	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	100	100	100	100	100	99	100	99	100	100	100	101	100	100	100	99	101	100	100	0	0	100	100	100

Table XXX. Rag—Departmental Cable Types Preferred for Sub Feeders in Per Cent of Replies Received

	CP	WY	WR	SCR	DKR	SPR	MR	FR	CR	BP	PBR	TR	GR	FR	WMR	RP	RC	RW	RB	HC	HWB	WPSR	WPC-DR	WPCO-DE
NRIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRIN	50	50	50	0	0	13	10	0	0	0	9	14	50	0	25	10	0	0	0	0	0	17	0	0
NRB	0	0	0	100	100	38	30	43	50	40	27	29	0	40	25	30	43	40	50	0	0	33	50	50
SRB	0	0	0	0	0	0	10	14	50	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	50	50	50	0	0	13	20	0	0	0	18	0	50	0	25	10	0	0	0	0	0	17	0	0
AVC	0	0	0	0	0	13	10	14	0	40	27	29	0	40	25	20	14	20	17	0	0	0	0	0
VCB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TP	0	0	0	0	0	13	10	14	0	20	9	14	0	0	0	10	29	20	17	0	0	33	50	50
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	13	10	14	0	0	9	14	0	20	0	10	14	20	17	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	100	100	100	100	100	103	100	99	100	100	99	100	100	100	100	100	100	100	101	0	0	100	100	100

Table XXXI. Rag—Departmental Cable Types Preferred for Generator Leads in Per Cent of Replies Received

	CP	WY	WR	SCR	DKR	SPR	MR	FR	CR	BP	PBR	TR[a]	GR	FR	WMR	RP	RC	RW	RB	HC	HWB	WPSR	WPC-DR	WPCO-DE
NRIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRB	0	0	0	0	0	0	33	0	0	0	0	38	0	0	0	0	0	0	0	0	0	0	0	0
SRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AVC	0	0	0	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0
VCB	0	0	0	0	0	0	33	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0
TP	0	0	0	0	0	100	33	0	0	0	0	13	0	0	100	0	0	0	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	0	0	0	0	0	100	99	0	0	0	0	102	0	0	100	0	0	0	0	0	0	0	0	0

[a] The turbine room only considered in considering the relative importance of cable types.

Table XXXII. Others[a]—Departmental Cable Types Preferred for Motor Leads in Per Cent of Replies Received

	CP	WY	WR	DR	WHR	SCR	DKR	SPR	MR	FR	CR	CZP	LR	BP	ER	RYR	PBR	TR	SBR	AMP	GR	FR	WMR	RP	RC	RW	RB	HC	HWB	WPSR	WPC-DR	WPCO-DE	GEN[b]
NRIN	23	40	27	25	30	27	33	19	15	19	50	20	25	20	20	22	13	12	11	18	27	14	21	25	100	100	100	100	100	33	50	33	17
SRIN	0	0	0	0	0	0	0	4	3	7	0	0	0	0	0	0	6	12	0	0	0	7	5	0	0	0	0	0	0	0	0	0	10
NRB	31	20	36	32	30	27	33	26	24	30	25	40	25	40	40	22	23	30	22	46	36	28	21	25	0	0	0	0	0	33	0	0	41
SRB	0	0	0	0	0	0	0	7	6	4	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	10	9	8	10	9	0	11	9	7	0	10	0	10	10	11	7	0	11	9	0	0	5	0	0	0	0	0	0	0	0	0	5
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	25	0	0
AVC	8	10	9	17	10	9	0	7	3	7	0	10	25	10	10	33	26	24	44	9	9	14	11	0	0	0	0	0	0	0	0	33	14
VCB	8	10	9	8	10	9	0	7	6	11	0	10	13	10	10	11	13	18	11	9	9	14	16	0	0	0	0	0	0	0	33	25	33	14
TP	31	10	9	8	10	18	33	19	32	15	25	10	13	10	10	0	3	6	0	9	18	14	16	50	0	0	0	0	0	0	33	25	33	14
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	3	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0
Totals	101	100	99	98	100	99	99	100	101	100	100	100	101	100	100	99	100	102	99	99	99	98	100	100	100	100	100	100	100	99	100	99	101

[a] "Others," impossible to classify as a particular branch of the industry. [b] Used everywhere throughout the mill for motor leads without respect to department.

Table XXXIII. Others[a]—Departmental Cable Types Preferred for Motor Control in Per Cent of Replies Received

	CP	WY	WR	DR	WHR	SCR	DKR	SPR	MR	FR	CR	CZP	LR	BP	ER	RYR	PBR	TR	SBR	AMP	GR	FR	WMR	RP	RC	RW	RB	HC	HWB	WPSR	WPC-DR	WPCO-DE	GEN[b]
NRIN	25	50	30	27	33	30	28	21	17	29	67	21	33	22	22	25	19	23	11	22	30	20	21	25	100	100	100	100	100	50	50	50	13
SRIN	0	0	10	9	11	10	14	8	10	12	0	11	0	11	11	13	8	15	11	11	10	20	14	0	0	0	0	0	0	0	0	0	15
NRB	17	13	30	27	22	20	28	17	17	24	33	33	17	33	33	13	15	15	22	33	30	20	14	0	0	0	0	0	0	0	0	0	35
SRB	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	13	10	9	11	10	0	8	7	6	0	11	0	11	11	13	4	0	11	11	0	0	7	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AVC	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
VCB	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	25	19	23	33	0	0	0	0	0	0	0	0	0	0	0	0	0	8
TP	58	25	20	18	22	30	28	42	38	24	0	22	33	22	22	13	23	15	11	22	30	30	43	75	0	0	0	0	0	50	50	50	25
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	4	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0
Totals	100	101	100	99	99	100	98	100	98	101	100	99	100	99	99	102	100	99	99	99	100	100	99	100	100	100	100	100	100	100	100	100	101

[a] "Others," impossible to classify as a particular branch of the industry. [b] Used everywhere throughout the mill for motor control without respect to department.

Table XXXIV. Others[a]—Departmental Cable Types Preferred for Lighting in Per Cent of Replies Received

	CP	WY	WR	DR	WHR	SCR	DKR	SPR	MR	FR	CR	CZP	LR	BP	ER	RYR	PBR	TR	SBR	AMP	GR	FR	WMR	RP	RC	RW	RB	HC	HWB	WPSR	WPC-DR	WPCO-DE	GEN[b]
NRIN	14	40	18	27	33	30	33	25	18	20	67	20	29	22	22	25	15	20	13	22	30	22	21	25	100	100	100	100	100	33	50	50	10
SRIN	0	0	0	0	0	0	0	8	7	15	0	0	0	0	0	0	11	13	0	0	0	11	7	0	0	0	0	0	0	0	0	0	20
NRB	29	30	55	46	44	40	33	17	18	25	33	50	43	56	56	50	11	13	50	56	40	33	29	0	0	0	0	0	0	33	0	0	35
SRB	0	0	0	0	0	0	0	12	14	10	0	0	0	0	0	0	7	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AVC	7	10	9	18	11	10	0	4	4	5	0	10	14	11	11	25	26	27	38	11	10	11	7	0	0	0	0	0	0	0	0	0	0
VCB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	7	0	0	0	0	0	0	0	0	0	0	0	0	25	0	8
TP	50	20	9	9	11	20	33	29	32	25	0	10	14	11	11	0	19	20	0	11	20	11	21	75	0	0	0	0	0	33	25	50	23
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
AS	0	0	9	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	100	100	100	100	99	100	99	99	101	100	100	100	100	100	100	100	100	100	101	100	100	99	99	100	100	100	100	100	100	99	100	100	102

[a] "Others," impossible to classify as a particular branch of the industry. [b] Used everywhere throughout the mill for lighting without respect to department.

Table XXXV. Others[a]—Departmental Cable Types Preferred for Prime Feeders in Per Cent of Replies Received

	CP	WY	WR	DR	WHR	SCR	DKR	SPR	MR	FR	CR	CZP	LR	BP	ER	RYR	PBR	TR	SBR	AMP	GR	FR	WMR	RP	RC	RW	RB	HC	HWB	WPSR	WPC-DR	WPCO-DE	GEN[b]
NRIN	46	56	33	20	25	33	29	32	25	22	50	25	29	25	22	29	23	24	29	22	30	25	33	60	50	50	50	50	100	60	67	50	7
SRIN	9	11	11	10	13	11	14	5	4	6	25	13	14	13	11	14	4	7	14	11	10	0	8	0	0	0	0	0	0	0	0	0	5
NRB	19	11	22	20	13	11	14	14	21	28	0	25	29	25	22	14	15	21	14	22	20	38	26	0	0	0	0	0	0	20	0	0	29
SRB	0	0	0	0	0	0	0	14	13	11	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
NRL	0	0	0	0	0	0	0	5	4	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	3
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
VCL	9	0	11	10	13	11	14	5	8	0	0	13	0	13	11	14	0	0	14	11	10	13	8	0	0	0	0	0	0	0	0	0	0
AVC	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	14	12	14	14	0	0	0	0	0	0	0	0	0	0	0	0	0	15
VCB	0	0	0	0	0	0	0	5	4	6	0	0	0	0	0	0	12	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
TP	9	0	11	10	13	11	14	5	4	6	0	13	14	13	11	0	0	0	0	11	10	13	0	0	0	0	0	0	0	0	0	0	10
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
AS	0	11	0	10	13	11	0	5	4	6	0	0	0	13	11	14	4	0	14	11	0	0	0	0	0	0	0	0	0	0	0	0	5
Copper bus	9	11	11	10	13	11	14	14	13	17	25	13	14	0	11	0	12	7	0	11	10	13	8	20	50	50	50	50	0	20	33	50	5
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	10	0	8	20	0	0	0	0	0	0	0	0	5
Totals	101	100	99	100	103	99	99	104	100	102	100	102	100	102	99	99	101	99	100	99	100	102	99	100	100	100	100	100	100	100	100	100	103

[a] "Others," impossible to classify as a particular branch of the industry. [b] Used everywhere throughout the mill for prime feeders without respect to departmen t.

Table XXXVI. Others[a]—Departmental Cable Types Preferred for Sub Feeders in Per Cent of Replies Received

	CP	WY	WR	DR	WHR	SCR	DKR	SPR	MR	FR	CR	CZP	LR	BP	ER	RYR	PBR	TR	SBR	AMP	GR	FR	WMR	RP	RC	RW	RB	HC	HWB	WPSR	WPC-DR	WPCO-DE	GEN[b]
NRIN	36	63	33	22	29	38	33	26	19	24	67	25	33	25	25	29	20	17	14	25	38	29	30	100	100	100	100	100	100	75	100	50	8
SRIN	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
NRB	27	25	33	44	43	38	50	32	35	41	33	50	50	50	50	43	30	42	43	50	50	57	60	0	0	0	0	0	0	25	0	0	32
SRB	0	0	0	0	0	0	0	16	12	12	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
NRL	9	13	11	11	14	13	0	11	8	6	0	13	0	13	13	14	5	0	14	13	0	0	10	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AVC	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	14	15	17	29	0	0	0	0	0	0	0	0	0	0	0	0	0	3
VCB	0	0	0	0	0	0	0	6	4	6	0	0	0	0	0	0	10	17	0	0	0	0	0	0	0	0	0	0	0	0	0	50	17
TP	27	0	11	11	14	13	17	11	12	12	0	13	17	13	13	0	0	8	0	13	13	14	0	0	0	0	0	0	0	0	0	0	15
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	99	101	99	99	100	102	100	102	98	101	100	101	100	101	101	100	100	101	100	101	101	100	100	100	100	100	100	100	100	100	100	100	104

[a] "Others," impossible to classify as a particular branch of the industry. [b] Used everywhere throughout the mill for sub feeders without respect to department.

Table XXXVII. Others[a]—Departmental Cable Types Preferred for Generator Leads in Per Cent of Replies Received

	CP	WY	WR	DR	WHR	SCR	DKR	SPR	MR	FR	CR	CZP	LR	BP	ER	RYR	PBR	TR	SBR	AMP	GR	FR	WMR	RP	RC	RW	RB	HC	HWB	WPSR	WPC-DR	WPCO-DE
NRIN	0	0	0	0	0	0	0	100	27	100	100	0	0	0	0	0	0	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRB	0	0	0	0	0	0	0	0	33	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRB	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	27	0	0	100	0	0	0	0	0	0	0	0	0	0	0
AVC	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCB	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TP	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	0	0	0	0	0	0	0	100	102	100	100	0	0	0	0	0	0	102	0	0	100	0	0	0	0	0	0	0	0	0	0	0

[a] "Others," impossible to classify as a particular branch of the industry. [b] Only turbine room considered in considering the relative importance of cable types.

Table XXXVIII. Cable Types Preferred in Chip Preparation Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						*Motor controls*						*Lighting*						*Prime feeders*						*Sub feeders*						*Generator leads*					
	Sulphate	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	27	9	0	0	0	23	47	13	0	0	0	25	41	11	0	0	0	14	29	13	0	0	0	46	39	7	0	0	0	36	67	100	0	0	0	0
SRIN	23	5	0	0	0	0	12	6	0	0	100	0	18	0	0	0	0	0	17	7	0	0	50	9	17	7	0	0	50	0	0	0	0	0	0	0
NRB	9	29	0	0	50	31	12	31	0	0	0	17	12	47	0	0	100	29	4	20	0	0	0	19	11	29	0	0	0	27	0	0	0	0	0	0
SRB	5	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	5	5	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	17	27	0	0	50	9	6	21	0	0	50	0	0	0	0	0	0	0
AVC	0	5	0	0	0	8	0	6	0	0	0	0	0	5	0	0	0	7	4	7	0	0	0	0	6	7	0	0	0	0	0	0	0	0	0	0
VCB	18	19	0	0	50	8	0	13	0	0	0	0	0	5	0	0	0	0	21	20	0	0	0	0	17	29	0	0	0	0	33	0	0	0	0	0
TP	5	19	0	0	0	31	29	19	0	0	0	58	29	26	0	0	0	50	0	0	0	0	0	9	0	0	0	0	0	27	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0
Other	5	5	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	102	101	0	0	100	101	100	100	0	0	100	100	100	99	0	0	100	100	100	101	0	0	100	101	102	100	0	0	100	99	100	100	0	0	0	0

Table XXXIX. Cable Types Preferred in Wood Yard Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						Motor controls						Lighting						Prime feeders						Sub feeders						Generator leads					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	33	19	0	0	0	40	44	20	25	0	0	50	44	15	33	0	0	40	27	13	0	0	0	56	41	7	0	0	0	63	100	100	0	0	0	0
SRIN	21	5	25	0	0	0	11	7	25	0	100	0	17	0	0	0	0	0	18	7	50	0	50	11	18	7	50	0	50	0	0	0	0	0	0	0
NRB	8	19	0	0	50	20	11	20	0	0	0	13	11	40	0	0	100	30	5	20	0	0	0	11	12	29	0	0	0	25	0	0	0	0	0	0
SRB	4	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	4	9	25	0	0	10	0	0	25	0	0	13	0	0	0	0	0	0	5	0	50	0	0	0	0	0	50	0	0	13	0	0	100	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	4	5	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	9	20	0	0	50	0	6	21	0	0	50	0	0	0	0	0	0	0
AVC	0	5	0	0	0	10	0	7	0	0	0	0	0	5	0	0	0	10	5	7	0	0	0	0	6	7	0	0	0	0	0	0	0	0	0	0
VCB	18	14	25	0	50	10	0	13	0	0	0	0	0	5	0	0	0	0	18	27	0	0	0	0	12	29	0	0	0	0	0	0	0	0	0	0
TP	4	19	25	0	0	10	33	20	25	0	0	25	28	25	33	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	5	33	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	11	6	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	4	5	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	100	100	100	0	100	100	99	101	100	0	100	101	100	100	99	0	100	100	101	101	100	0	100	100	101	100	100	0	100	101	100	100	100	0	0	0

Table XL. Cable Types Preferred in Wood Room Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						Motor controls						Lighting						Prime feeders						Sub feeders						Generator leads					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	25	9	20	0	0	27	41	11	0	0	0	30	32	10	0	0	0	18	30	12	33	0	0	33	39	6	33	0	0	33	100	100	0	0	0	0
SRIN	21	4	0	0	0	0	12	5	0	0	100	10	16	0	0	0	0	0	20	6	0	0	50	11	17	6	0	0	50	11	0	0	0	0	0	0
NRB	8	34	0	0	50	36	12	33	0	0	0	30	11	50	0	0	100	55	5	19	0	0	0	22	11	31	0	0	0	33	0	0	0	0	0	0
SRB	4	0	20	0	0	0	0	0	0	0	0	0	0	5	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	4	4	20	0	0	9	0	0	50	0	0	10	0	0	33	0	0	0	0	0	33	0	0	0	0	0	33	0	0	11	0	0	100	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	4	9	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	10	25	0	0	50	11	6	19	0	0	50	0	0	0	0	0	0	0
AVC	0	4	0	0	0	9	0	5	0	0	0	0	5	5	0	0	0	9	5	6	0	0	0	0	11	13	0	0	0	0	0	0	0	0	0	0
VCB	17	17	20	0	50	9	0	17	0	0	0	0	0	5	0	0	0	0	20	19	0	0	0	0	11	25	0	0	0	0	0	0	0	0	0	0
TP	4	13	20	0	0	9	35	17	50	0	0	20	37	25	33	0	0	9	0	0	0	0	0	11	0	0	33	0	0	11	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	10	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0
Other	4	4	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	101	98	100	0	100	99	100	100	100	0	100	100	101	100	99	0	100	100	100	99	99	0	100	99	101	100	99	0	100	99	100	100	100	0	0	0

Table XLI. Cable Types Preferred in Digester Room Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						Motor controls						Lighting						Prime feeders						Sub feeders						Generator leads					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	27	9	0	0	0	25	50	11	0	0	0	27	38	9	0	0	0	27	26	13	0	0	0	20	38	7	0	0	0	22	100	100	0	0	0	0
SRIN	23	5	0	0	0	0	13	6	0	0	0	9	19	0	0	0	0	0	21	7	0	0	0	10	19	7	0	0	0	0	0	0	0	0	0	0
NRB	9	32	0	0	0	32	13	33	0	0	0	27	13	48	0	0	0	46	5	27	0	0	0	20	13	27	0	0	0	44	0	0	0	0	0	0

SRB	5	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	5	5	0	0	0	8	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	5	5	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	11	20	0	0	0	10	6	20	0	0	0	0	0	0	0	0	0	0
AVC	0	5	0	0	0	17	0	6	0	0	0	9	6	5	0	0	0	18	5	7	0	0	0	10	6	13	0	0	0	11	0	0	0	0	0	0
VCB	18	14	0	0	0	8	0	11	0	0	0	0	0	5	0	0	0	0	21	20	0	0	0	0	13	27	0	0	0	0	0	0	0	0	0	0
TP	5	23	0	0	0	8	25	22	0	0	0	18	25	29	0	0	0	9	0	0	0	0	0	10	0	0	0	0	0	11	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	10	6	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0
Other	5	5	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	102	102	0	0	0	98	101	101	0	0	0	99	100	101	0	0	0	100	100	101	0	0	0	100	100	100	0	0	0	99	100	100	0	0	0	0

Table XLII. Cable Types Preferred in Washer Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						*Motor controls*						*Lighting*						*Prime feeders*						*Sub feeders*						*Generator leads*					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	27	33	0	0	0	30	50	33	0	0	0	33	40	33	0	0	0	33	26	25	0	0	0	25	38	25	0	0	0	29	100	100	0	0	0	0
SRIN	23	0	0	0	0	0	7	0	0	0	0	11	20	0	0	0	0	0	21	0	0	0	0	13	19	0	0	0	0	0	0	0	0	0	0	0
NRB	9	3	0	0	0	30	14	33	0	0	0	22	7	50	0	0	0	44	5	0	0	0	0	13	13	0	0	0	0	43	0	0	0	0	0	0
SRB	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	5	0	0	0	0	10	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	25	0	0	0	13	6	25	0	0	0	0	0	0	0	0	0	0
AVC	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	11	5	0	0	0	0	0	6	25	0	0	0	0	0	0	0	0	0	0
VCB	18	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	21	25	0	0	0	0	13	25	0	0	0	0	0	0	0	0	0	0
TP	5	17	0	0	0	10	29	17	0	0	0	22	33	17	0	0	0	11	0	0	0	0	0	13	0	0	0	0	0	14	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	13	6	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0
Other	5	17	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	102	100	0	0	0	100	100	100	0	0	0	99	100	100	0	0	0	99	100	100	0	0	0	103	101	100	0	0	0	100	100	100	0	0	0	0

Table XLIII. Cable Types Preferred in Screen Room Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						*Motor controls*						*Lighting*						*Prime feeders*						*Sub feeders*						*Generator leads*					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	31	9	0	0	0	27	44	12	0	0	0	30	36	10	0	0	0	30	24	13	0	0	0	33	38	7	0	0	0	38	100	100	0	0	0	0
SRIN	22	5	20	0	0	0	13	6	34	0	0	10	21	0	0	0	0	0	19	7	50	0	0	11	19	7	50	0	0	0	0	0	0	0	0	0
NRB	9	33	0	0	100	27	13	35	0	0	100	20	7	50	0	0	100	40	5	20	0	100	100	11	13	27	0	100	100	38	0	0	0	0	0	0
SRB	4	0	20	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	4	5	0	0	0	9	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	4	5	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	10	27	0	0	0	11	6	20	0	0	0	0	0	0	0	0	0	0
AVC	0	5	0	25	0	9	0	6	0	25	0	0	0	5	0	25	0	10	5	7	0	0	0	0	6	27	0	0	0	0	0	0	0	0	0	0
VCB	17	19	40	50	0	9	0	12	0	0	0	0	0	5	0	0	0	0	19	20	0	0	0	0	13	13	0	0	0	0	0	0	0	0	0	0
TP	4	14	20	25	0	18	31	18	66	75	0	30	36	25	100	75	0	20	10	0	50	0	0	11	0	0	50	0	0	13	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	11	6	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0
Other	4	5	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	99	100	100	100	100	99	100	101	100	100	100	100	100	100	100	100	100	100	102	101	100	100	100	99	101	101	100	100	100	102	100	100	0	0	0	0

Table XLIV. Cable Types Preferred in Decker Room Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						Motor controls						Lighting						Prime feeders						Sub feeders						Generator leads					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	27	14	0	0	0	33	44	17	0	0	0	28	38	13	0	0	0	33	32	8	0	0	0	29	47	8	0	0	0	33	100	100	0	0	0	0
SRIN	23	7	14	0	0	0	13	8	34	0	0	14	19	0	0	0	0	0	21	8	33	0	0	14	20	8	33	0	0	0	0	0	0	0	0	0
NRB	9	29	0	0	100	33	13	25	0	0	100	28	6	53	0	0	100	33	5	17	0	0	100	14	13	25	0	0	100	50	0	0	0	0	0	0
SRB	5	0	14	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	5	7	29	0	0	0	0	0	0	0	0	0	0	0	33	0	0	0	0	0	33	0	0	0	0	0	33	0	0	0	0	0	100	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	5	7	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	11	33	0	0	0	14	0	25	0	0	0	0	0	0	0	0	0	0
AVC	0	7	0	0	0	0	0	8	0	0	0	0	6	7	0	0	0	0	5	8	0	0	0	0	7	9	0	0	0	0	0	0	0	0	0	0
VCB	18	7	29	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	21	17	0	0	0	0	13	25	0	0	0	0	0	0	0	0	0	0
TP	5	14	14	0	0	33	31	17	66	0	0	28	31	20	67	0	0	33	0	0	33	0	0	14	0	0	33	0	0	17	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0
Other	5	7	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	102	99	100	0	100	99	101	99	100	0	100	98	100	100	100	0	100	99	100	99	99	0	100	99	100	100	99	0	100	100	100	100	100	0	0	0

Table XLV. Cable Types Preferred in Stock Preparation Room Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						Motor controls						Lighting						Prime feeders						Sub feeders						Generator leads					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	25	11	0	0	0	19	41	13	25	0	0	21	33	12	25	0	0	25	31	13	0	0	0	32	39	7	0	0	0	26	75	100	0	0	0	100
SRIN	21	0	14	0	0	4	12	0	25	0	14	8	17	0	0	0	14	8	21	0	25	0	11	5	17	0	25	0	13	0	0	0	0	0	0	0
NRB	8	37	0	38	44	26	12	40	0	45	57	17	6	53	0	45	57	17	5	20	0	38	33	14	11	33	0	43	38	32	0	0	0	0	0	0
SRB	4	0	14	12	0	7	0	0	0	11	0	0	0	0	0	11	0	12	0	0	0	13	0	14	0	0	0	14	0	16	0	0	0	0	0	0
NRL	4	5	29	0	0	11	0	0	0	0	0	8	0	0	25	0	0	4	0	0	25	13	0	5	0	0	25	14	0	11	0	0	100	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	8	5	0	0	11	0	0	7	0	0	0	0	0	0	0	0	0	0	11	27	25	13	33	5	6	20	0	14	13	0	25	0	0	0	0	0
AVC	0	5	0	0	11	7	0	7	0	0	14	0	0	6	0	0	14	4	5	7	0	0	0	0	11	13	0	0	13	0	0	0	0	0	0	0
VCB	17	21	29	38	22	7	0	13	0	0	0	4	0	6	0	0	0	0	21	27	0	13	0	5	11	27	25	14	0	6	0	0	0	0	0	0
TP	8	11	14	12	11	19	35	13	50	45	14	42	44	24	50	45	14	29	0	0	25	0	11	5	0	0	25	0	13	11	0	0	0	0	100	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	5	6	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	11	14	0	0	0	0	13	0	0	0	0	0	0	0
Other	4	5	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	99	100	100	100	99	100	100	100	100	101	99	100	100	101	100	101	99	99	99	101	100	103	99	104	101	100	100	99	103	102	100	100	100	0	100	100

Table XLVI. Cable Types Preferred in Machine Room Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						Motor controls						Lighting						Prime feeders						Sub feeders						Generator leads					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	22	13	13	0	0	15	37	18	20	0	0	17	30	10	20	0	0	18	23	12	20	0	0	25	32	6	20	0	0	19	29	18	0	0	0	27
SRIN	19	5	13	0	0	3	11	6	20	0	13	10	15	0	0	0	0	7	18	6	20	0	10	4	21	6	20	0	10	0	6	0	0	0	0	0
NRB	7	31	0	29	40	24	11	24	0	38	50	17	5	42	0	45	75	18	5	19	0	33	30	21	11	31	0	38	30	35	6	36	0	0	33	33

SRB	4	0	13	14	10	6	0	0	0	13	13	3	0	5	20	11	13	14	0	0	0	11	10	13	0	0	0	13	10	12	0	0	0	0	0	7
NRL	4	5	24	0	0	9	0	0	0	0	0	7	0	0	20	0	0	4	0	0	20	11	0	4	0	0	20	13	0	8	0	0	100	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	4	5	0	0	10	0	0	6	0	0	0	0	0	0	0	0	0	0	14	25	0	11	30	8	5	19	0	13	20	8	6	19	0	0	0	7
AVC	7	5	0	0	10	3	11	6	0	0	13	0	15	5	0	0	0	4	9	6	0	0	0	0	11	12	0	0	10	0	18	9	0	0	0	7
VCB	26	18	24	43	20	6	5	12	0	0	0	3	5	5	0	0	0	0	23	25	20	22	0	4	16	25	20	25	0	4	35	9	0	0	33	7
TP	4	14	13	14	10	32	26	24	60	50	13	38	30	32	40	45	13	32	0	0	20	0	10	4	0	0	20	0	10	12	0	0	0	0	33	7
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	4	5	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	10	13	0	0	0	0	10	0	0	9	0	0	0	0
Other	4	4	0	0	0	3	0	6	0	0	0	3	0	0	0	0	0	4	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
Totals	101	100	100	100	100	101	101	102	100	100	102	98	100	99	100	101	101	101	101	100	100	99	100	100	100	99	100	100	100	98	100	100	100	0	99	102

Table XLVII. Cable Types Preferred in Finishing Room Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						*Motor controls*						*Lighting*						*Prime feeders*						*Sub feeders*						*Generator leads*					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	36	14	17	0	0	19	50	17	40	0	0	29	41	15	50	0	0	20	29	17	25	0	0	22	41	10	25	0	0	24	75	0	100	0	0	100
SRIN	18	7	17	0	0	7	11	8	20	0	0	12	18	0	0	0	0	15	19	8	25	0	0	6	18	10	25	0	0	0	0	0	0	0	0	0
NRB	7	29	0	29	44	30	11	25	0	38	57	24	12	54	0	0	72	25	10	25	0	33	43	28	12	30	0	38	43	41	0	0	0	0	0	0
SRB	4	0	16	14	11	4	0	0	0	13	14	0	0	8	0	38	14	10	0	0	0	11	14	11	0	0	0	11	14	12	0	0	0	0	0	0
NRL	4	0	0	0	0	7	0	0	0	0	0	6	0	0	0	13	0	0	0	0	0	11	0	0	0	0	0	13	0	6	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	4	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	14	17	0	11	14	0	6	20	0	13	0	0	0	0	0	0	0	0
AVC	0	0	0	0	11	7	0	0	0	0	14	0	0	0	0	0	0	5	5	0	0	0	0	0	6	0	0	0	14	0	0	0	0	0	0	0
VCB	18	7	33	43	11	11	0	0	0	0	0	6	0	0	0	0	0	0	14	8	25	22	0	6	12	20	25	25	0	6	25	0	0	0	0	0
TP	7	36	17	14	11	15	28	42	40	50	14	24	29	23	50	50	14	25	0	17	25	0	14	6	0	10	25	0	14	12	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	6	6	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	14	17	0	0	0	0	14	0	0	0	0	0	0	0
Other	4	7	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	102	100	100	100	99	100	100	100	100	101	99	101	100	100	100	101	100	100	101	100	100	99	99	102	101	100	100	100	99	101	100	0	100	0	0	100

Table XLVIII. Cable Types Preferred in Coating Room Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						*Motor controls*						*Lighting*						*Prime feeders*						*Sub feeders*						*Generator leads*					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	17	17	0	0	0	50	47	17	33	0	0	67	40	17	50	0	0	67	28	17	0	0	0	50	40	14	0	0	0	67	100	100	0	0	0	100
SRIN	27	0	33	0	0	0	13	0	33	0	0	0	20	0	0	0	0	0	22	0	50	0	0	25	20	0	50	0	0	0	0	0	0	0	0	0
NRB	11	0	0	0	33	25	13	33	0	25	33	33	13	49	0	25	67	33	6	17	0	17	50	0	13	29	0	20	50	33	0	0	0	0	0	0
SRB	0	33	0	33	33	0	0	0	0	25	33	0	0	0	0	25	33	0	0	0	0	17	50	0	0	0	0	20	50	0	0	0	0	0	0	0
NRL	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	20	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	6	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	11	17	0	17	0	0	7	14	0	20	0	0	0	0	0	0	0	0
AVC	0	17	0	0	0	0	0	17	0	0	0	0	7	17	0	0	0	0	6	17	0	0	0	0	7	15	0	0	0	0	0	0	0	0	0	0
VCB	22	17	35	33	0	0	0	17	0	0	0	0	0	0	0	0	0	0	22	33	50	17	0	0	13	29	50	20	0	0	0	0	0	0	0	0
TP	6	17	34	33	33	25	27	0	34	50	33	0	20	17	50	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	25	0	0	0	0	0	0	0	0	0	0	0	0
Other	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	101	101	100	99	99	100	100	101	100	100	99	100	100	100	100	100	100	100	101	101	100	102	100	100	100	101	100	100	100	100	100	100	0	0	0	100

Table XLIX. Cable Types Preferred in Causticizing Plant Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						Motor controls						Lighting						Prime feeders						Sub feeders						Generator leads					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	35	0	0	0	0	20	50	0	0	0	0	22	39	0	0	0	0	20	27	0	0	0	0	25	39	0	0	0	0	25	100	0	0	0	0	0
SRIN	23	0	0	0	0	0	11	0	0	0	0	11	17	0	0	0	0	0	23	0	0	0	0	13	22	0	0	0	0	0	0	0	0	0	0	0
NRB	0	50	0	0	0	40	11	0	0	0	0	33	11	0	0	0	0	50	5	0	0	0	0	25	11	0	0	0	0	50	0	0	0	0	0	0
SRB	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	4	0	0	0	0	10	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	13	6	0	0	0	0	0	0	0	0	0	0	0
AVC	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	10	5	0	0	0	0	0	6	50	0	0	0	0	0	0	0	0	0	0
VCB	13	50	0	0	0	10	0	100	0	0	0	0	0	100	0	0	0	0	18	100	0	0	0	0	11	50	0	0	0	0	0	0	0	0	0	0
TP	4	0	0	0	0	10	28	0	0	0	0	22	33	0	0	0	0	10	0	0	0	0	0	13	0	0	0	0	0	13	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	9	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0
Other	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	101	100	0	0	0	100	100	100	0	0	0	99	100	100	0	0	0	100	101	100	0	0	0	101	101	100	0	0	0	101	100	0	0	0	0	0

Table L. Cable Types Preferred in Lime Recovery Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						Motor controls						Lighting						Prime feeders						Sub feeders						Generator leads					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	20	0	0	0	0	25	41	0	0	0	0	33	39	0	0	0	0	29	23	0	0	0	0	29	28	0	0	0	0	33	100	0	0	0	0	0
SRIN	24	0	0	0	0	0	11	0	0	0	0	0	17	0	0	0	0	0	23	0	0	0	0	14	22	0	0	0	0	0	0	0	0	0	0	0
NRB	12	100	0	0	0	25	11	100	0	0	0	17	6	100	0	0	0	43	5	0	0	0	0	29	11	0	0	0	0	50	0	0	0	0	0	0
SRB	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	12	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0
AVC	4	0	0	0	0	25	5	0	0	0	0	17	11	0	0	0	0	14	9	0	0	0	0	0	11	100	0	0	0	0	0	0	0	0	0	0
VCB	16	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0
TP	4	0	0	0	0	13	26	0	0	0	0	33	28	0	0	0	0	14	0	0	0	0	0	14	0	0	0	0	0	17	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	6	0	0	0	0	0	0	0	0	0	0	0
Other	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	100	100	0	0	0	100	99	100	0	0	0	100	101	100	0	0	0	100	101	0	0	0	0	100	101	100	0	0	0	100	100	0	0	0	0	0

Table LI. Cable Types Preferred in Bleach Plant Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						Motor controls						Lighting						Prime feeders						Sub feeders						Generator leads					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	29	7	0	0	0	20	47	10	0	0	0	22	45	18	0	0	0	22	30	20	0	0	0	25	36	8	0	0	0	25	100	100	0	0	0	0
SRIN	21	7	0	0	0	0	11	10	0	0	0	11	17	0	0	0	0	0	20	10	0	0	0	13	21	8	0	0	0	0	0	0	0	0	0	0
NRB	13	29	0	0	20	40	11	20	0	0	50	33	11	18	0	0	60	56	5	20	0	0	50	25	14	25	0	0	40	50	0	0	0	0	0	0

SRB	4	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	10	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	4	7	0	0	20	0	0	10	0	0	0	0	0	0	0	0	0	0	15	20	0	0	25	13	7	17	0	0	0	0	0	0	0	0
AVC	0	7	0	0	40	10	0	10	0	0	50	0	0	9	0	0	20	11	5	20	0	0	0	0	7	17	0	0	40	0	0	0	0	0
VCB	17	21	0	0	20	10	0	20	0	0	0	0	0	9	0	0	0	0	20	10	0	0	0	0	14	17	0	0	0	0	0	0	0	0
TP	8	14	0	0	0	10	32	20	0	0	0	22	28	36	0	0	20	11	0	0	0	0	25	13	0	0	0	0	20	13	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	4	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	100	99	0	0	100	100	101	100	0	0	100	99	101	99	0	0	100	100	100	100	0	0	100	102	99	100	0	0	100	101	100	100	0	0	0	0

Table LII. Cable Types Preferred in Evaporator Room Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						*Motor controls*						*Lighting*						*Prime feeders*						*Sub feeders*						*Generator leads*					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	27	0	0	0	0	20	47	0	0	0	0	22	33	0	0	0	0	22	26	0	0	0	0	22	33	0	0	0	0	25	75	0	0	0	0	0
SRIN	23	0	0	0	0	0	12	0	0	0	0	11	17	0	0	0	0	0	16	0	0	0	0	11	20	0	0	0	0	0	25	0	0	0	0	0
NRB	14	0	0	0	0	40	12	0	0	0	0	33	11	0	0	0	0	56	5	0	0	0	0	22	13	0	0	0	0	50	0	0	0	0	0	0
SRB	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	10	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0	11	7	0	0	0	0	0	0	0	0	0	0	0
AVC	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	11	5	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0
VCB	18	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	21	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0
TP	5	0	0	0	0	10	29	0	0	0	0	22	39	0	0	0	0	11	0	0	0	0	0	11	0	0	0	0	0	13	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	11	7	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0
Other	5	100	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	102	100	0	0	0	100	100	100	0	0	0	99	100	0	0	0	0	100	100	0	0	0	0	99	100	0	0	0	0	101	100	0	0	0	0	0

Table LIII. Cable Types Preferred in Recovery Room Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						*Motor controls*						*Lighting*						*Prime feeders*						*Sub feeders*						*Generator leads*					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	22	0	0	0	0	22	41	0	0	0	0	25	33	0	0	0	0	25	23	0	0	0	0	29	30	0	0	0	0	29	100	0	0	0	0	0
SRIN	22	0	0	0	0	0	11	0	0	0	0	13	14	0	0	0	0	0	23	0	0	0	0	14	20	0	0	0	0	0	0	0	0	0	0	0
NRB	11	0	0	0	0	22	11	0	0	0	0	13	11	0	0	0	0	50	5	0	0	0	0	14	10	0	0	0	0	43	0	0	0	0	0	0
SRB	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	11	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	7	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	14	0	0	0	0	14	5	0	0	0	0	0	0	0	0	0	0	0
AVC	4	0	0	0	0	33	5	0	0	0	0	25	14	0	0	0	0	25	9	0	0	0	0	14	15	0	0	0	0	14	0	0	0	0	0	0
VCB	19	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0
TP	7	0	0	0	0	0	31	0	0	0	0	13	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	14	5	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Totals	100	0	0	0	0	99	99	0	0	0	0	102	101	0	0	0	0	100	101	0	0	0	0	99	100	0	0	0	0	100	100	0	0	0	0	0

Table LIV. Cable Types Preferred in Power Boiler Room Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						Motor controls						Lighting						Prime feeders						Sub feeders						Generator leads					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	18	9	17	0	0	13	35	10	33	0	0	19	30	9	50	0	0	15	18	11	40	0	0	23	21	5	40	0	0	20	50	100	100	0	0	0
SRIN	21	5	17	0	0	6	10	5	17	0	11	8	15	0	0	0	0	11	23	5	20	0	10	4	21	6	20	0	9	0	0	0	0	0	0	0
NRB	11	23	0	13	36	23	10	25	0	22	44	15	5	41	0	22	63	11	5	16	0	22	30	15	11	28	0	25	27	30	0	0	0	0	0	0
SRB	4	5	17	13	0	6	0	0	0	11	0	0	0	5	0	11	0	7	0	0	0	11	0	15	0	0	0	13	0	20	0	0	0	0	0	0
NRL	0	0	0	0	0	7	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	13	0	5	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	11	5	0	0	9	0	5	5	0	0	0	0	5	0	0	0	0	0	14	21	0	11	30	0	5	17	0	13	18	0	0	0	0	0	0	0
AVC	4	18	16	38	36	26	5	20	16	33	33	19	15	14	25	33	25	26	9	21	0	22	10	12	16	17	0	25	27	15	0	0	0	0	0	0
VCB	21	18	17	38	18	13	5	15	0	0	0	8	5	9	0	0	0	7	23	21	20	11	0	12	16	28	20	13	0	10	50	0	0	0	0	0
TP	7	14	16	0	0	3	30	15	34	33	11	23	25	23	25	33	13	19	0	0	20	0	10	0	0	0	20	0	9	0	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	4	5	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	10	12	0	0	0	0	9	0	0	0	0	0	0	0
Other	4	5	0	0	0	3	0	5	0	0	0	4	0	0	0	0	0	4	0	5	0	0	0	4	5	0	0	0	0	0	0	0	0	0	0	0
Totals	101	102	100	102	99	100	100	100	100	99	99	100	100	101	100	99	101	100	101	100	100	99	100	101	100	101	100	102	99	100	100	100	100	0	0	0

Table LV. Cable Types Preferred in Turbine Room Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						Motor controls						Lighting						Prime feeders						Sub feeders						Generator leads					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	25	9	0	0	0	12	47	12	0	0	0	23	37	9	0	0	0	20	25	0	0	0	0	29	35	10	0	0	0	17	25	14	0	0	0	27
SRIN	21	9	17	0	0	12	12	12	25	0	17	15	16	0	0	0	0	13	20	9	33	0	17	7	18	10	33	0	14	0	6	7	25	0	0	7
NRB	13	27	0	17	50	30	12	25	0	29	50	15	11	55	0	29	50	13	5	18	0	25	33	21	12	20	0	29	29	42	6	14	0	50	38	7
SRB	4	9	17	17	0	0	0	0	0	14	0	0	0	9	0	14	0	0	0	0	0	13	0	0	0	0	0	14	0	0	0	0	0	17	0	7
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	14	0	0	0	7	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	8	9	0	0	0	0	6	13	0	0	0	0	0	0	0	0	0	0	15	36	33	13	0	0	6	30	33	14	0	0	6	29	25	0	0	27
AVC	0	9	0	17	33	24	0	13	0	14	33	23	5	9	0	14	50	27	5	9	0	13	17	14	6	10	0	14	29	17	19	7	0	33	25	7
VCB	21	18	50	50	17	18	0	12	25	0	0	8	0	0	33	0	0	7	20	19	0	13	0	21	12	20	0	14	0	17	31	7	50	0	13	7
TP	4	0	16	0	0	6	24	0	50	44	0	15	32	18	67	43	0	20	0	0	33	0	17	0	0	0	33	0	14	8	0	0	0	0	13	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	17	0	6	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	7	0	0	0	0	14	0	6	0	0	0	13	13
Other	4	9	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	15	0	0	0	0
Totals	100	99	100	101	100	102	101	100	100	101	100	99	101	100	100	100	100	100	100	100	99	103	101	99	101	100	99	99	100	101	99	100	100	100	102	102

Table LVI. Cable Types Preferred in Sulphur Burner Room Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						Motor controls						Lighting						Prime feeders						Sub feeders						Generator leads					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Wastepaper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	0	5	0	0	0	11	0	7	0	0	0	11	0	6	0	0	0	13	0	14	0	0	0	29	0	7	0	0	0	14	0	100	0	0	0	0
SRIN	0	5	0	0	0	0	0	7	0	0	0	11	0	6	0	0	0	0	0	7	0	0	0	14	0	7	0	0	0	0	0	0	0	0	0	0
NRB	0	32	0	0	0	22	0	20	0	0	0	22	0	41	0	0	0	50	0	21	0	0	0	14	0	27	0	0	0	43	0	0	0	0	0	0

SRB	0	5	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	11	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	5	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	29	0	0	0	14	0	20	0	0	0	0	0	0	0	0	0	0
AVC	0	16	0	0	0	44	0	20	0	0	0	33	0	12	0	0	0	38	0	7	0	0	0	14	0	13	0	0	0	29	0	0	0	0	0	0
VCB	0	11	0	0	0	11	0	7	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0
TP	0	16	0	0	0	0	0	27	0	0	0	11	0	29	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	5	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	0	100	0	0	0	99	0	102	0	0	0	99	0	100	0	0	0	101	0	99	0	0	0	100	0	101	0	0	0	100	0	100	0	0	0	0

Table LVII. Cable Types Preferred in Acid Making Plant Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						Motor controls						Lighting						Prime feeders						Sub feeders						Generator leads					
Results	Sulphate	Sulphite	Groundwood	Waste paper	Rag	Other	Sulphate	Sulphite	Groundwood	Waste paper	Rag	Other	Sulphate	Sulphite	Groundwood	Waste paper	Rag	Other	Sulphate	Sulphite	Groundwood	Waste paper	Rag	Other	Sulphate	Sulphite	Groundwood	Waste paper	Rag	Other	Sulphate	Sulphite	Groundwood	Waste paper	Rag	Other
NRIN	0	8	0	0	0	18	0	11	0	0	0	22	0	9	0	0	0	22	0	13	0	0	0	22	0	6	0	0	0	25	0	100	0	0	0	0
SRIN	0	4	0	0	0	0	0	5	0	0	0	11	0	5	0	0	0	0	0	7	0	0	0	11	0	6	0	0	0	0	0	0	0	0	0	0
NRB	0	29	0	0	0	46	0	21	0	0	0	33	0	33	0	0	0	56	0	20	0	0	0	22	0	22	0	0	0	50	0	0	0	0	0	0
SRB	0	4	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	9	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	4	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	27	0	0	0	11	0	17	0	0	0	0	0	0	0	0	0	0
AVC	0	8	0	0	0	9	0	11	0	0	0	0	0	10	0	0	0	11	0	7	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0
VCB	0	17	0	0	0	9	0	11	0	0	0	0	0	5	0	0	0	0	0	20	0	0	0	0	0	22	0	0	0	0	0	0	0	0	0	0
TP	0	21	0	0	0	9	0	31	0	0	0	22	0	33	0	0	0	11	0	0	0	0	0	11	0	6	0	0	0	13	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0
O ther	0	4	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	0	99	0	0	0	99	0	101	0	0	0	99	0	100	0	0	0	100	0	101	0	0	0	99	0	102	0	0	0	101	0	100	0	0	0	0

Table LVIII. Cable Types Preferred in Grinder Room Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						Motor controls						Lighting						Prime feeders						Sub feeders						Generator leads					
Results	Sulphate	Sulphite	Groundwood	Waste paper	Rag	Other	Sulphate	Sulphite	Groundwood	Waste paper	Rag	Other	Sulphate	Sulphite	Groundwood	Waste paper	Rag	Other	Sulphate	Sulphite	Groundwood	Waste paper	Rag	Other	Sulphate	Sulphite	Groundwood	Waste paper	Rag	Other	Sulphate	Sulphite	Groundwood	Waste paper	Rag	Other
NRIN	100	16	14	100	0	27	100	21	17	100	0	30	0	15	20	0	0	30	0	15	25	0	0	30	0	8	25	0	0	38	0	50	0	0	0	0
SRIN	0	0	14	0	0	0	0	0	17	0	100	10	0	8	0	0	0	0	0	0	25	0	50	10	0	0	25	0	50	0	0	0	0	0	0	0
NRB	0	37	0	0	50	36	0	29	0	0	0	30	0	38	20	0	100	40	0	15	0	0	0	20	0	0	0	50	0	50	0	50	0	0	0	0
SRB	0	5	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	0	14	0	0	0	0	0	16	0	0	0	0	0	20	0	0	0	0	0	25	0	0	0	0	0	25	0	0	0	0	0	50	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	5	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	·0	0	38	0	0	50	10	0	25	0	0	50	0	0	0	0	0	0	100
AVC	0	5	0	0	0	9	0	7	0	0	0	0	0	8	0	0	0	10	0	8	0	100	0	0	0	8	0	100	0	0	0	0	0	0	0	0
VCB	0	16	29	0	50	9	0	7	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	25	0	0	0	0	0	0	50	0	0	0
TP	0	11	15	0	0	18	0	21	50	0	0	30	100	31	40	0	0	20	0	0	25	0	0	10	0	0	25	0	0	13	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	5	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0
Totals	100	100	100	100	100	99	100	99	100	100	100	100	100	100	100	0	100	100	100	99	100	100	100	100	100	100	100	100	100	101	0	100	100	0	0	100

Table LIX. Cable Types Preferred in Filter Room Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						Motor controls						Lighting						Prime feeders						Sub feeders						Generator leads					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	67	25	0	0	0	14	50	28	0	0	0	20	33	12	0	0	0	22	0	14	0	0	0	25	0	14	0	0	0	29	0	100	0	0	0	0
SRIN	0	13	0	0	0	7	0	0	0	0	0	20	0	13	0	0	0	11	0	14	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0
NRB	0	37	0	0	60	28	0	43	0	0	60	20	0	37	0	0	60	33	0	14	0	100	50	38	0	14	0	100	40	57	0	0	0	0	0	0
SRB	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	0	100	0	0	0	0	0	100	0	0	0	0	0	100	0	0	0	0	0	100	0	0	0	0	0	100	0	0	0	0	100	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	29	0	0	25	13	0	29	0	0	0	0	0	0	0	0	0	0
AVC	0	0	0	0	40	14	0	0	0	40	0	0	0	0	0	0	20	11	0	0	0	0	0	0	50	0	0	0	40	0	0	0	0	0	0	0
VCB	0	12	0	67	0	14	0	14	0	0	0	0	0	12	0	0	0	0	0	29	0	0	0	0	0	29	0	0	0	0	0	0	0	0	0	0
TP	33	0	0	33	0	14	50	0	0	100	0	30	67	13	0	100	20	11	0	0	0	0	0	13	0	0	0	0	0	14	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	0	0	0	0	50	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	13	0	0	0	0	20	0	0	C	0	0	0	0
Other	0	13	0	0	0	7	0	14	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C
Totals	100	100	100	100	100	98	100	99	100	100	100	100	100	100	100	100	100	99	100	100	100	100	100	102	100	100	100	100	100	100	0	100	100	0	0	0

Table LX. Cable Types Preferred in Wet Machine Room Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						Motor controls						Lighting						Prime feeders						Sub feeders						Generator leads					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	100	11	50	0	0	21	50	13	0	0	0	21	33	13	0	0	0	21	25	14	50	50	0	33	33	8	50	50	0	30	0	100	0	0	0	0
SRIN	0	0	0	0	0	5	0	0	0	0	25	14	0	7	0	0	0	7	0	0	0	0	25	8	0	0	0	0	25	0	0	0	0	0	0	0
NRB	0	32	0	0	40	21	0	27	0	0	25	14	0	40	50	0	50	29	0	21	0	50	25	26	0	31	0	50	25	60	0	0	0	0	0	0
SRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	5	50	0	0	5	0	7	50	0	0	7	0	0	50	0	0	7	0	0	50	0	0	8	0	0	50	0	0	10	0	0	100	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	5	0	0	0	5	0	7	0	0	0	0	0	0	0	0	0	0	50	29	0	0	50	8	0	23	0	0	25	0	0	0	0	0	0	0
AVC	0	5	0	0	20	11	0	7	0	0	25	0	0	7	0	0	25	7	0	7	0	0	0	0	0	8	0	0	25	0	0	0	0	0	0	0
VCB	0	21	0	0	20	16	0	13	0	0	0	0	0	7	0	0	0	0	0	21	0	0	0	0	33	23	0	0	0	0	0	0	0	0	0	0
TP	0	16	0	0	20	16	50	20	50	0	25	43	67	27	0	0	25	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0
WP	0	0	0	100	0	0	0	0	0	100	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0	0	0	0	0	33	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	5	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0
Totals	100	100	100	100	100	100	100	101	100	100	100	99	100	101	100	100	100	99	100	99	100	100	100	99	99	101	100	100	100	100	0	100	100	0	100	0

Table LXI. Cable Types Preferred in Rag Preparation Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						Motor controls						Lighting						Prime feeders						Sub feeders						Generator leads					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	0	0	0	0	0	25	0	0	0	0	0	25	0	0	0	0	0	25	0	0	0	0	0	60	0	0	0	0	0	100	0	0	0	0	0	0
SRIN	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	10	0	0	0	0	0	0	0
NRB	0	0	0	0	40	25	0	0	0	0	50	0	0	0	0	0	63	0	0	0	0	0	33	0	0	0	0	0	30	0	0	0	0	0	0	0

SRB	0	0	0	0	10	0	0	0	0	0	13	0	0	0	0	0	13	0	0	0	0	0	11	0	0	0	0	0	10	0	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0	0	0	0	0	10	0	0	0	0	0	0	0
AVC	0	0	0	0	20	0	0	0	0	0	25	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0
VCB	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TP	0	0	0	0	0	50	0	0	0	0	0	75	0	0	0	0	13	75	0	0	0	0	11	0	0	0	0	0	10	0	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	20	0	0	0	0	10	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0
Totals	0	0	0	0	100	100	0	0	0	0	101	100	0	0	0	0	102	100	0	0	0	0	99	100	0	0	0	0	100	100	0	0	0	0	0	0

Table LXII. Cable Types Preferred in Rag Cooking Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						*Motor controls*						*Lighting*						*Prime feeders*						*Sub feeders*						*Generator leads*					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	0	0	0	0	0	100	0	0	0	0	0	100	0	0	0	0	0	100	0	0	0	0	0	50	0	0	0	0	0	100	0	0	0	0	0	0
SRIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRB	0	0	0	0	43	0	0	0	0	0	67	0	0	0	0	0	57	0	0	0	0	0	50	0	0	0	0	0	43	0	0	0	0	0	0	0
SRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	14	0	0	0	0	0	0	0
AVC	0	0	0	0	14	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCB	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TP	0	0	0	0	14	0	0	0	0	0	17	0	0	0	0	0	43	0	0	0	0	0	17	0	0	0	0	0	29	0	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	50	0	0	0	0	14	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	0	0	0	0	99	100	0	0	0	0	101	100	0	0	0	0	100	100	0	0	0	0	101	100	0	0	0	0	100	100	0	0	0	0	0	0

Table LXIII. Cable Types Preferred in Rag Washing Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						*Motor controls*						*Lighting*						*Prime feeders*						*Sub feeders*						*Generator leads*					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	0	0	0	0	0	100	0	0	0	0	0	100	0	0	0	0	0	100	0	0	0	0	0	50	0	0	0	0	0	100	0	0	0	0	0	0
SRIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRB	0	0	0	0	60	0	0	0	0	0	60	0	0	0	0	0	50	0	0	0	0	0	50	0	0	0	0	0	40	0	0	0	0	0	0	0
SRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0
AVC	0	0	0	0	20	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0
VCB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TP	0	0	0	0	20	0	0	0	0	0	20	0	0	0	0	0	50	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	50	0	0	0	0	20	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	0	0	0	0	100	100	0	0	0	0	100	100	0	0	0	0	100	100	0	0	0	0	100	100	0	0	0	0	100	100	0	0	0	0	0	0

Table LXIV. Cable Types Preferred in Rag Bleaching Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						Motor controls						Lighting						Prime feeders						Sub feeders						Generator leads					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	0	0	0	0	0	100	0	0	0	0	0	100	0	0	0	0	0	100	0	0	0	0	0	50	0	0	0	0	0	100	0	0	0	0	0	0
SRIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRB	0	0	0	0	60	0	0	0	0	0	60	0	0	0	0	0	50	0	0	0	0	0	60	0	0	0	0	0	50	0	0	0	0	0	0	0
SRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0
AVC	0	0	0	0	20	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0
VCB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TP	0	0	0	0	20	0	0	0	0	0	20	0	0	0	0	0	50	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	50	0	0	0	0	17	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	0	0	0	0	100	100	0	0	0	0	100	100	0	0	0	0	100	100	0	0	0	0	100	100	0	0	0	0	101	100	0	0	0	0	0	0

Table LXV. Cable Types Preferred in Hemp Cooking Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						Motor controls						Lighting						Prime feeders						Sub feeders						Generator leads					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	0	0	0	0	0	100	0	0	0	0	0	100	0	0	0	0	0	100	0	0	0	0	0	50	0	0	0	0	0	100	0	0	0	0	0	0
SRIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRB	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AVC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	0	0	0	0	0	100	0	0	0	0	100	100	0	0	0	0	100	100	0	0	0	0	0	100	0	0	0	0	0	100	0	0	0	0	0	0

Table LXVI. Cable Types Preferred in Hemp Washing and Bleaching Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						Motor controls						Lighting						Prime feeders						Sub feeders						Generator leads					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	0	0	0	0	0	100	0	0	0	0	0	100	0	0	0	0	0	100	0	0	0	0	0	100	0	0	0	0	0	100	0	0	0	0	0	0
SRIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AVC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TP	0	0	0	0	100	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	0	0	0	0	100	100	0	0	0	0	100	100	0	0	0	0	100	100	0	0	0	0	0	100	0	0	0	0	0	100	0	0	0	0	0	0

Table LXVII. Cable Types Preferred in Waste Paper Storage and Sorting Room Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						*Motor controls*						*Lighting*						*Prime feeders*						*Sub feeders*						*Generator leads*					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	0	0	33	0	0	33	0	0	50	0	0	50	0	0	50	0	0	33	0	0	50	0	0	60	0	0	50	0	0	75	0	0	100	0	0	0
SRIN	0	0	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	17	0	0	0	0	0	0	0
NRB	0	0	0	25	33	33	0	0	0	25	50	0	0	0	0	25	75	33	0	0	0	67	40	20	0	0	0	67	33	25	0	0	0	0	0	0
SRB	0	0	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	17	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	20	0	0	0	0	17	17	0	0	0	0	0	0	0
AVC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCB	0	0	34	50	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TP	0	0	0	25	17	33	0	0	50	75	25	50	0	0	50	75	25	33	0	0	50	0	20	0	0	0	50	0	33	0	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	0	0	100	100	100	99	0	0	100	100	100	100	0	0	100	100	100	99	0	0	100	101	100	100	0	0	100	101	100	100	0	0	100	0	0	0

Table LXVIII. Cable Types Preferred in Waste Paper Cutting and Dusting Room Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						*Motor controls*						*Lighting*						*Prime feeders*						*Sub feeders*						*Generator leads*					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	0	0	0	0	0	50	0	0	0	0	0	50	0	0	0	0	0	50	0	0	0	0	0	67	0	0	0	0	0	100	0	0	0	0	0	0
SRIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRB	0	0	0	100	50	0	0	0	0	100	50	0	0	0	0	100	50	0	0	0	0	0	100	0	0	0	0	0	50	0	0	0	0	0	0	0
SRB	0	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	0	0	0	0	50	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	0	0	0	0	50	0	0	0	0	0	0	0	0
AVC	0	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCB	0	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TP	0	0	0	0	50	25	0	0	100	0	50	50	0	0	100	0	50	25	0	0	100	0	0	0	0	0	100	0	50	0	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	0	0	100	100	100	100	0	0	100	100	100	100	0	0	100	100	100	100	0	0	100	100	100	100	0	0	100	100	100	100	0	0	0	0	0	0

Table LXIX. Cable Types Preferred in Waste Paper Cooking and Deinking Room Dept. Industry Wise in Per Cent of Replies Received

	Motor leads						Motor controls						Lighting					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	0	0	0	0	0	33	0	0	0	0	0	50	0	0	0	0	0	50
SRIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRB	0	0	0	100	50	0	0	0	0	100	50	0	0	0	0	100	50	0
SRB	0	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AVC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCB	0	0	50	0	0	33	0	0	0	0	0	0	0	0	0	0	0	0
TP	0	0	0	0	50	33	0	0	100	0	50	50	0	0	100	0	50	50
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	0	0	100	100	100	99	0	0	100	100	100	100	0	0	100	100	100	100

	Prime feeders						Sub feeders						Generator leads					
Results	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*	*Sulphate*	*Sulphite*	*Groundwood*	*Waste paper*	*Rag*	*Other*
NRIN	0	0	0	0	0	50	0	0	0	0	0	50	0	0	0	0	0	0
SRIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRB	0	0	0	0	50	0	0	0	0	0	50	0	0	0	0	0	0	0
SRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRL	0	0	0	50	0	0	0	0	0	50	0	0	0	0	0	0	0	0
SRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCL	0	0	0	50	0	0	0	0	0	50	0	0	0	0	0	0	0	0
AVC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VCB	0	0	0	0	0	0	0	0	0	0	0	50	0	0	0	0	0	0
TP	0	0	100	0	50	0	0	0	100	0	50	0	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper bus	0	0	0	0	0	50	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	0	0	100	100	100	100	0	0	100	100	100	100	0	0	0	0	0	0

Table LXX. Common Causes of Cable Failure (Normal Operating Conditions)

	Sulphate		Sulphite		Groundwood		Wastepaper		Rags		Other		Entire industry lumped	
Cause[a]	%	*No. of answers*	%	*No. of answers*	%	*No. of answers*	%	*No. of answers*	%	*No. of answers*	%	*No. of answers*	%	*No. of answers*
1	16.2	13	7.4	7	25	3	13.8	4	9.55	2	11.75	18	12	47
1a	6.25	5	0.00	0	0.00	0	6.9	2	0.00	0	0.65	1	2	8
1b	3.75	3	4.25	4	0.00	0	3.5	1	0.00	0	0.00	0	2	8
1c	1.25	1	2.12	2	0.00	0	0.00	0	0.00	0	0.00	0	0.8	3
2	10	8	15.95	15	25	3	17.2	5	28.6	6	18.3	28	17	65
2a	0.00	0	5.3	5	0.00	0	3.5	1	14.3	3	5.23	8	4	17
3	1.25	1	0.00	0	0.00	0	0.00	0	0.00	0	1.3	2	0.8	3
4	12.5	10	17	16	16.7	2	10.5	3	19.2	4	17.6	27	16	62
5	10	8	6.4	6	8.3	1	13.8	4	9.55	2	10.45	16	10	37
6	5	4	7.4	7	0.00	0	6.9	2	0.00	0	3.92	6	5	19
7	7.5	6	5.3	5	0.00	0	0.00	0	4.77	1	2.61	4	4	16
8	0.00	0	1.06	1	0.00	0	0.00	0	0.00	0	0.00	0	0.26	1
9	1.25	1	2.12	2	8.3	1	0.00	0	0.00	0	0.66	1	1.3	5
10	0.00	0	2.12	2	0.00	0	0.00	0	0.00	0	0.00	0	0.52	2
10a	1.25	1	1.06	1	0.00	0	0.00	0	4.77	1	1.3	2	1.3	5
10b	5	4	1.06	1	0.00	0	0.00	0	0.00	0	3.26	5	2.6	10
10c	1.25	1	1.06	1	0.00	0	0.00	0	0.00	0	0.00	0	0.52	2
11	1.25	1	3.18	3	0.00	0	3.5	1	0.00	0	5.23	8	3.4	13
12	3.75	3	2.12	2	0.00	0	3.5	1	0.00	0	3.26	5	2.8	11
13	3.75	3	1.06	1	0.00	0	6.9	2	0.00	0	0.65	1	1.8	7
14	3.75	3	6.04	6	8.3	1	3.5	1	0.00	0	7.2	11	5.6	22
15	2.5	2	6.04	6	8.3	1	3.5	1	4.77	1	3.92	6	4	17
16	0.00	0	1.06	1	0.00	0	0.00	0	0.00	0	0.00	0	0.26	1
17	1.25	1	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.26	1
18	1.25	1	0.00	0	0.00	0	3.75	1	4.77	1	0.66	1	1	4
19	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.66	1	0.26	1
Totals	99.55	80	99.10	94	99.90	12	100.75	29	100.28	21	98.61	151	99.48	387

[a] Common causes of cable failure (normal operating conditions):

1. Physical damage to insulation during installation.
1a. Nonobservance of recommended cable bending radii.
1b. Not careful in making up cable stresscones, potheads, etc. Overload.
1c. Steam or other high-temperature pipes too close to cable ducts. Soldered lugs and solderless connectors.
2. Deterioration of cable insulation due to age.
2a. Deterioration of cable insulation due to oxidation.
3. Imperfection in insulation during manufacture.
4. Presence of moisture in cable.
5. Deterioration of cable due to exposure to oil.
6. Deterioration of cable due to exposure to acids.
7. Deterioration of cable due to exposure to alkali.
8. Deterioration of cable due to exposure to ozone.
9. Deterioration of cable due to exposure to sunlight.
10. Deterioration of cable due to exposure to rats biting lead.
10a. Deterioration of cable due to exposure to condensate in conduit.
10b. Deterioration of cable due to exposure to heat.
10c. Deterioration of cable due to exposure to vibration in junction box.
11. Deterioration of cable due to exposure to water.
12. Corrosion of lead sheath due to electrolysis.
13. Corrosion of lead sheath due to chemical reaction.
14. Improper cable termination.
15. Improper cable splicing.
16. Connector failure.
17. Obstruction in conduit.
18. Physical damage after installation
19. Lightning.

Table LXXI. Predominant Location of Above Failures

Location[a]	Sulphate		Sulphite		Groundwood		Waste paper		Rags		Other		Entire industry lumped	
	%	No. of answers	%	No. of answers	%	No. of answers	%	No. of answers	%	No. of answers	%	No. of answers	%	No. of answers
1	21.2	7	28	7	28.6	2	33.3	2	22.2	2	32	16	28	36
2	24.2	8	24	6	43	3	33.3	2	22.2	2	14	7	21	28
3	27.2	9	12	3	0.00	0	16.7	1	33.3	3	14	7	18	23
3a	0.00	0	4	1	0.00	0	0.00	0	0.00	0	0.00	0	0.8	1
4	3.03	1	4	1	0.00	0	0.00	0	0.00	0	0.00	0	1.5	2
4a	0.00	0	4	1	0.00	0	0.00	0	0.00	0	0.00	0	0.8	1
4b	0.00	0	4	1	0.00	0	0.00	0	0.00	0	0.00	0	0.8	1
5	9.1	3	4	1	14.3	1	0.00	0	11.1	1	10	5	8	11
6	6.06	2	8	2	14.3	1	0.00	0	11.1	1	6	3	7	9
7	0.00	0	4	1	0.00	0	0.00	0	0.00	0	0.00	0	0.8	1
8	3.03	1	4	1	0.00	0	0.00	0	0.00	0	0.00	0	1.5	2
9	3.03	1	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.8	1
10	3.03	1	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.8	1
11	0.00	0	0.00	0	0.00	0	16.7	1	0.00	0	0.00	0	0.8	1
12	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	2	1	0.8	1
13	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	16	8	6	8
14	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	4	2	1.5	2
15	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	2	1	0.8	1
Totals	99.88	33	100.00	25	100.20	7	100.00	6	99.90	9	100.00	50	99.7	130

[a] Predominant location of above failures:
1. Cable terminations.
2. Splices.
3. Cable bends.
3a. Cable bends—physical damage during installation.
4. Conduits.
4a. Acid.
4b. Presence of moisture, from condensation, has caused many failures where conduit runs from inside the building to location outside the building.
5. Junction boxes and LB's due to penetration of insulation by cover screws.
6. In conduits.
7. Improper bushing termination in runs to switches and starters.
8. Conduit fittings with covers missing permitting moisture and other matter to enter and damage the cable at that point.
9. Underground.
10. Arc of insulators on overhead lines (saltcake and water).
11. Conduit not pitched to drain and plugged to prevent condensation from cross circulation.
12. Low point of run where water settles.
13. General.
14. No particular location.
15. Long cable runs.

Table LXXII. Preferred Methods of Installing Wires and Cables Showing Percentages and Numbers of Answers

Method of Installation	Sulphate		Sulphite		Groundwood		Waste paper		Rags		Other		Entire industry lumped	
	%	No. of answers	%	No. of answers	%	No. of answers	%	No. of answers	%	No. of answers	%	No. of answers	%	No. of answers
1	65.5	104	63.5	94	92.5	37	76.8	43	07.7	55	69.5	280	69.4	613
2	12.5	20	7.45	11	0.00	0	12.5	7	11.5	9	11.1	45	10.4	92
3	1.89	3	3.38	5	0.00	0	0.00	0	0.00	0	1.99	8	1.8	16
4	2.5	4	4.72	7	0.00	0	1.79	1	2.5	2	2.73	11	2.7	24
5	8.8	14	4.5	6	0.00	0	5.26	3	6.42	5	2.73	11	4.4	39
6	5.65	9	4.5	6	2.5	1	0.00	0	1.28	1	2.98	12	3.3	29
7	0.00	0	3.02	3	0.00	0	1.79	1	0.00	0	0.495	2	0.68	6
8	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.745	3	0.34	3
9	1.26	2	4.05	6	0.00	0	0.00	0	0.00	0	0.247	1	1.02	9
10	0.00	0	0.67	1	2.5	1	0.00	0	0.00	0	1.74	7	1.02	9
11	1.89	3	0.67	1	2.5	1	1.79	1	3.85	3	1.74	7	1.8	16
12	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.247	1	0.11	1
13	0.00	0	2.7	4	0.00	0	0.00	0	0.00	0	0.745	3	0.79	7
14	0.00	0	1.35	2	0.00	0	0.00	0	0.00	0	0.00	0	0.22	2
15	0.00	0	0.00	0	0.00	0	0.00	0	3.85	3	2.48	10	1.47	13
16	0.00	0	1.35	2	0.00	0	0.00	0	0.00	0	0.247	1	0.33	3
17	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.247	1	0.11	1
Totals	99.99	159	99.86	148	100.00	40	99.93	56	100.10	78	99.923	403	99.89	883

Method of installation. Index to "LXXII":
1. (SCE) Rigid steel galvanized conduit exposed.
2. (SCU) Rigid steel galvanized conduit underground.
3. (TFE) Transite or fiber duct exposed.
4. (TFU) Transite or fiber duct underground.
5. (IAC) Interlocked armored cable.
6. (SSA) Self-supporting aerial cable.
7. Overhead on pole line.
8. Copper bus enclosed in sheet steel gutter.
9. Racks.
10. Transite tray.
11. Bus.
12. Cement raceway.
13. Aluminum conduit exposed.
14. Single-conductor open run, three on flat.
15. Exposed wire.
16. Ground lay.
17. Interlocked armored cable, neoprene covered.

UNITED STATES PATENTS ON PAPERMAKING

First Quarter, 1952 — *Compiled by CLARENCE J. WEST*

THE following list of United States patents has been compiled from the current numbers of the Official Gazette of the United States Patent Office. Because, as a rule, only one claim is published in the Gazette, it is not claimed that the list is complete; also it is possible that the list may contain some patents that do not apply specifically to pulp and paper manufacture.

Copies of any of the following patents can be obtained from the United States Patent Office, Washington 25, D. C., by sending twenty-five cents for each patent desired.

January 1, 1952

2,580,386. Letter sheet. Ida M. Jonansson, Deje, Sweden. Filed June 1, 1948. 1 claim. (Cl. 229-92.1.) The bottom margin of a letter sheet has an oblong gummed flap by means of which it can be sealed.

2,580,391. Fiberboard construction. Glen E. Babcock, Vernon L. Johnsen, and Allen K. Smith, assignors to the United States of America as represented by the Secretary of Agriculture. Filed Feb. 23, 1951. 4 claims. (Cl. 154-140.) A fiberboard laminating glue consists of 20 parts of soya bean protein and flour, 2.5 to 10 parts of a copolymer of styrene, and an α,β-unsaturated dicarboxylic acid, 2.5 to 10 parts of saponified rosin, and sodium hydroxide in water; the glue contains 18 to 26% solids and has a pH of 10.5 to 11.

2,580,461. Ultraviolet-radiation impervious wrapping material. Irwin A. Pearl, assignor to Sulphite Products Corp. Appleton. Wis. Filed Aug. 27, 1947. 12 claims. (Cl 88-109.) A transparent food wrapper (e.g., glassine, parchment, cellophane) is impregnated with an ester of 3-methoxy-4-hydroxybenzoic acid.

2,580,496. Separation of rosin acids. Harold H. Zeiss, assignor to The Fulwal Chemical Corp., New York, N. Y. Filed July 14, 1948. 7 claims. (Cl. 260-100.) A method is given; for the separation of dehydroabietic acid from disproportionated rosin as its alkali salt.

2,580,562. Boxmaking machine. William B. Leavens, Jr., West Orange, N. J. Filed Oct. 22, 1949. 18 claims. (Cl. 93-44.) Box blanks are formed about a series of continuously moving form blocks.

2,580,568. Cigarette paper. Robinson E. Matthews and Ward D. Harrison, assignors to Ecusta Paper Corp., Pisgah Forest, N. C. Filed May 16, 1950. 5 claims. (Cl. 131-15.) A combustible cigarette paper contains a calcium carbonate filler and 0.2 to 0.4% ammonium phosphate (as PO_4); such paper gives a grayish-white, flaky, cohesive ash throughout the length of the cigarette.

2,580,586. Paper box. Joseph A. O'Reilly, Bellingham, Wash. Filed June 13, 1949. 4 claims. (Cl. 229-7.) A rigid paper container for liquids and granular materials has an outside slip-fit cover which is applied after the container is filled.

2,580,608. Forming cigarette paper. Milton O. Schur and Robert M. Levy, assignors to Ecusta Paper Corp., Pisgah Forest, N. C. Filed April 25, 1946. 2 claims. (Cl. 92-21.) A cigarette paper contains calcium carbonate as a filler and the reaction product from 2.5% sodium hydroxide and 1.25% phosphoric acid.

2,580,609. Cigarette paper. Milton O. Schur and Robert M. Levy, assignors to Ecusta Paper Corp., Pisgah Forest, N. C. Filed Aug. 2, 1950. 12 claims. (Cl. 131-15.) A cigarette paper with calcium carbonate as filler contains 0.05 to 0.06% of a quaternary ammonium salt—e.g., tetra(2-hydroxyethyl)-ammonium phosphate.

2,580,610. Cigarette paper. Milton O. Schur and Robert M. Levy, assignors to Ecusta Paper Corp., Pisgah Forest, N. C. Filed May 29, 1951. 2 claims. (Cl. 131-15.) A cigarette paper with calcium carbonate filler contains 0.1 to 1% ammonium phosphate and 0.002 to 0.05% phosphoric acid.

2,580,611. Cigarette paper. Milton O. Schur and Robert M. Levy, assignors to Ecusta Paper Corp., Pisgah Forest, N. C. Filed June 23, 1951. 3 claims. (Cl. 131-15.) A cigarette paper with calcium carbonate filler contains the product from 0.5 to 5% sodium hydroxide and 0.5 to 5% phosphoric acid.

2,580,665. Method for forming paper can bodies. Robert M. Dunning and Reynolds Guyer, assignors to Waldorf Paper Products Co., St. Paul, Minn. Filed June 2, 1945. 11 claims. (Cl. 93-94.) A can body is formed of sheets of paperboard which are bent into cylindrical form and laminated with a thermoplastic adhesive.

2,580,712. Container for packaging merchandise. Abraham E. Weisberg, New York, N. Y. Filed June 3, 1949. 1 claim. (Cl. 229-55.) A multiwall bag for textiles and the like is formed of glassine and Pliofilm joined along their respective margins.

2,580,846. Machine for folding carton inserts. Gordon B. Sayre and Oscar Winz, assignors to Boonton Molding Co., Boonton, N. J. Filed May 14, 1947. 23 claims. (Cl. 93-1.) Apparatus for folding inserts or spacers for cartons of various sizes.

2,581,058. Coatings for insulation board. John K. Wise, assignor to United States Gypsum Co., Chicago, Ill. Filed July 21, 1947. 5 claims. (Cl. 106-214.) A composition suitable for application to wet insulating board consists of an aqueous gelatinized starch vehicle and an ester of a fatty acid with 12 to 24 carbon atoms and a polyethylene glycol with a molecular weight of 3000 to 4000.

2,581,076. Decorated wallboard and method of making same. Thomas P. Camp, assignor to United States Gypsum Co., Chicago, Ill. Filed March 1, 1946. 9 claims. (Cl. 154-86.) A plastic slurry of gypsum base core material is laminated with a decorative paper sheet (coated with a protein solution) and dried.

2,581,105 Textile container with slotted corners. Melvin T. Hunsworth, assignor to Container Corp. of America, Chicago, Ill. Filed May 25, 1948. 5 claims. (Cl. 229-23.) The container comprises identical top and bottom sections which can be partially telescoped.

2,581,115. Machine for setting-up cartons. David Levkoff, Great Neck, N. Y. Filed June 15, 1949. 9 claims. (Cl. 93-53.)

2,581,143. Stuff treatment apparatus. Cyrus E. Robertson, assignor to The Noble & Wood Machine Co., Hoosick Falls, N. Y. Filed April 2, 1947. 1 claim. (Cl. 92-26.) A centrifugal junk extractor is designed for repulping used paper, board, and the like containing foreign materials.

2,581,186. Paper having improved printing characteristics. Barrett K. Green, assignor to The National Cash Register Co., Dayton, Ohio. Filed Nov. 18, 1948. 8 claims. (Cl. 117-152.) A printing paper is coated with a zeolite material to render it resistant to ink bleed.

2,581,210. Positive pressure machine for forming continuous strips of asbestos-cement compositions and the like. Alvan D. Simpson, assignor to The Forming Machine Co., of America, Inc., Bound Brook, N. J. Filed April 29, 1948. 10 claims. (Cl. 92-43.) A cylinder machine is adapted for the formation of asbestos shingles and siding from a water suspension of asbestos and cement.

2,581,222. Bending process. Alvie E. Varner, assignor to Masonite Corp., Laurel Miss. Filed July 19, 1948. 2 claims. (Cl. 18-56.) A process for the angular bending a thick porous fiber blank.

2,581,237. Dispensing container. Roger H. Casler, assignor of one half to Ex-Cell-O Corp., Detroit, Mich., and one half to Ace Carton Corp., Chicago, Ill. Filed Sept. 27, 1946. 16 claims. (Cl. 229-17.) A container top and protective cover flap for a paperboard milk container.

2,581,242. Friction drum winding machine. Charles A. Dickhaut, assignor to John Waldron Corp., New Brunswick, N. J. Filed Aug. 25, 1947. 15 claims. (Cl. 242-65.) The winding drum provides a uniform winding pressure and permits the support of the bundle independently of the winding drum.

2,581,289. Disk nozzle shower device. Bruno E. Prevost, assignor to John W. Bolton & Sons, Inc., Lawrence, Mass. Filed Feb. 9, 1949. 6 claims. (Cl. 299-59.) A disk-type spray nozzle is designed for installation in pipes whose cross-sectional diameter is only slightly greater than the diameter of the nozzle.

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2,581,400. Carton. William G. Freel and Samuel F. Jones,

C. J. WEST, Chairman, TAPPI Bibliography Committee; Editor, The Institute of Paper Chemistry, Appleton, Wis.

assignors to William P. Frankenstein, Cincinnati, Ohio. Filed Sept. 9, 1947. 3 claims. (Cl. 229-31.) A double-wall folding carton is constructed from stock which is finished on one side only.

2,581,421. Method and apparatus for making structural elements. Nathaniel A. Lombard and Thomas L. Taggart; said Lombard assignor to Douglas Aircraft Co., Inc., Santa Monica, Calif. Filed April 27, 1948. 33 claims. (Cl. 154-1.8.) A method and apparatus for the manufacture of honeycombed core spacer for laminated articles, such as housing walls.

2,581,447. Box liner spreading jig. Joseph Rutkiewicz and Gasparre Grano, Philadelphia, Pa. Filed Oct. 24, 1945. 1 claim. (Cl. 93-36.01.) A jig is designed for the insertion of a paper liner or envelope into an open container.

2,581,491 Apparatus for setting up boxes. William F. Linstedt, assignor to Kraft Foods Co., Chicago, Ill. Filed Nov. 26, 1943. 6 claims. (Cl. 93-39.) Means for inserting tubular box wall elements into unfolded board tray elements.

2,581,516. Cup and integral straw. Meyer Cohen, Flushing, N. Y. Filed Oct. 10, 1947. 6 claims. (Cl. 229-7.) A drinking straw is formed as an integral portion of the wall of the cup.

2,581,539. Closure cap. William J. Keith, assignor to Keith-Peabody, Inc., Brookline, Mass. Filed May 9, 1946. 3 claims. (Cl. 93-1.) A screw-type closure cap is formed of several layers of paper or other thin, nonmetallic material.

2,581,617. Device for barking of logs and the like. Nikolai Alfsen, Oslo, Norway. Filed July 30, 1947. 5 claims. (Cl. 144-208.) A mechanical barker comprises two cooperating, coplanar peeling wheels which rotate in the same direction but at different peripheral speeds.

2,581,635. Wood fiber base material and process for making the same. Edwin P. Cox, assignor to The Champion Paper and Fibre Co., Hamilton, Ohio. Filed May 27, 1944. 3 claims. (Cl. 154-133.) A laminated wood fiber product is composed of not less than 0.8 gram per cc. of cellulosic wood fiber which is oriented and arranged as in the original wood and is impregnated with 33 to 67% of a phenolformaldehyde resin.

2,581,652. Method of manufacturing sheet wood. Worth C. Goss, assignor to United States Sheetwood Co., Seattle, Wash. Filed Jan. 19, 1948. 11 claims. (Cl. 18-47.5.) An adhesive for lignocellulosic fibers consists of brown rotted wood.

2,581,654. Dry process for making composite consolidated with controlled presteaming of the raw material. Earl G. Hollonquist, assignor to Plywood Research Foundation, Tacoma, Wash. Filed Nov. 21. 1949. 3 claims. (Cl. 18-47.5.) Wood chips are steamed 10 to 30 minutes at 75 p.s.i., the defibered product is mixed with a phenolformaldehyde resin, and formed under heat and pressure.

2,581,664. Container. Morton B. Jameson, assignor to Waldorf Paper Products Co., St. Paul, Minn. Filed June 7, 1946. 4 claims. (Cl. 206-52.) A container for shipping calendars and the like.

2,581,685. Impregnation of absorbent material. Wallace A. McMillan, assignor to The Texas Co., New York, N. Y. Filed June 16, 1948. 9 claims. (Cl. 117-92.) Asphalt roofing is formed by saturating with asphalt at 250 to 450°F. containing 0.1 to 10 p.p.m. of a dimethylsilicone polymer.

2,581,711. Mill roll stand. Louis W. Roselius, assignor to S & S Corrugated Paper Machinery Co., Inc., Brooklyn, N. Y. Filed April 14, 1947. 2 claims. (Cl. 242-58.) A stand is adaptable for the rotatable support of a mill roll of heavy kraft paper.

2,581,790. Industrial and papermakers' felt. Percival T. Gates, assignor to Drycor Felt Co., Belleville, N. J. Filed March 1, 1948. 6 claims. (Cl. 28-79.) In a woven papermaking felt the nap surfaces are produced by the needling of pile fleeces to the woven felt fabric.

2,581,801. Multiply bag tubing machine. Marcel Lienart, assignor to St. Regis Paper Co., New York, N. Y. Filed June 18, 1948. 14 claims. (Cl. 93-77.) The machine is adapted for the manufacture of multiwall paper tubes for stepped-end bags, which are formed into finished bags on a bottoming machine.

2,581,826. Bag. Stanley G. Yount, Los Angeles, Calif. Filed Sept. 29, 1947. 3 claims. (Cl. 229-55.) A large multiwall paper bag is adapted for covering large articles of furniture.

2,581,944. Container. John S. Donnell, assignor to Florida Fibre Box Co., Sarasota, Fla. Filed Aug. 9, 1950. 5 claims. (Cl. 229-19.) A container consists of an open tray and an open-end sleeve adapted to receive the tray.

2,581,993 Process of making acoustical tile. Grant S. Willey and Orcutt W. Frost, assignors to United States Gypsum Co., Chicago, Ill. Filed Dec. 6 1948. 2 claims. (Cl. 18-47.5.) The surface of an insulation board is densified by heat and pressure to form a skin coat thereon, after which semielliptical grooves are cut in the surface.

2,582,037. Coating composition containing polyethylene and wax and paper coated therewith. James B. Hyde, assignor to Crown Zellerbach Corp., San Fransicso, Calif. Filed Nov. 12, 1947. 13 claims. (Cl. 260-28.5.) The coating agent consists of 65 parts microcrystalline wax, 20 parts paraffin wax, 10 parts of a polyethylene polymer, and 5 parts of a polyisobutylene polymer; the waxed paper will not block in a roll or stack.

2,582,054. Pulping process. Jacques B. M. Michon, assignor to La Cellophane, Paris, France. Filed Sept. 12, 1946. 4 claims. (Cl. 92-13.) An alkaline process suitable for straw, grasses, bagasse, and the like.

2,582,149. Manifolding paper. Douglas A. Newman, assignor to Columbia Ribbon and Carbon Manufacturing Co., Inc., Glen Cove, N. Y. Filed 27, 1945. 4 claims. (Cl. 282-28.) The paper is cold printed with an ink which contains dispersed unmelted wax particles and then subjected to heat (infrared lamps).

2,582,183. Cup or glass-supporting plate. Walter Weidler, Milwaukee, Wis. Filed Sept. 22, 1947. 4 claims. (Cl. 229-2.5.)

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2,582,286. Bag closure. Arthur E. Schenck, assignor to Bemis Bro. Bag Co. Minneapolis, Minn. Filed June 16, 1947. 1 claim. (Cl. 229-62.) A method of closing a bag of the intucked type.

2,582,346. Cooky bag. Charles D. Mullnix, Los Angeles, Calif. Filed March 29, 1946. 1 claim. (Cl. 229-55.) A cellophane bag has a paperboard stiffening element.

2,582,347. Planographic printing. Douglas A. Newman, assignor to Columbia Ribbon and Carbon Manufacturing Co., Inc., Glen Cove, N. Y. Filed March 8, 1945. 24 claims. (Cl. 101-149.2.) A planographic master comprises a wet-strength paper plate, which has a film of water-insoluble carboxymethylcellulose around the image and over the background of the plate.

2,582,365. Drier roll. Walter Westphal, assignor to Rexford Paper Co. Milwaukee, Wis. Filed May 19, 1948. 7 claims. (Cl. 34-124.) A jacketed drier roll is equipped with a stationary condensate siphon pipe, the inner end of which is directed toward the lowermost portion of the roll.

2,582,393. Carton blank handling machine. Louis Perilli, Waltham, Mass. Filed Feb. 25, 1949. 16 claims. (Cl. 93-53). A method of erecting flat box blanks.

2,582,407. Process for coating paper. William H. Barrett and Bernard K. Asdell, assignors to Minnesota and Ontario Paper Co., Minneapolis, Minn. Filed May 29, 1946. 5 claims. (Cl. 117-111.) A method of applying coating material to a paper web by means of rolls; after drying, a second coat is applied.

2,582,429. Winding machine. Henry L. Haswell, assignor to Ecusta Paper Corp., Pisgah, Forest, N. C. Filed Aug. 20, 1946. 3 claims. (Cl. 242-65.) A paper winder includes means for the horizontal displacement of the winding mandrel so that the paper roll is positioned during winding without any of the weight resting on the driving roll.

2,582,459. Composition for oil well cementing. Richard A. Salathiel, assignor to Standard Oil Development Co., Elizabeth, N. J. Filed Nov. 3, 1948. 6 claims. (Cl. 106-90.) The cementing agent contains Portland cement, bentonite, and calcium lignosulphonate.

2,582,476. Display container for individually wrapped articles of merchandise and supporting tray therefor. Kenneth T. Buttery, assignor to Sutherland Paper Co., Kalamazoo, Mich. Filed June 20, 1949. 7 claims. (Cl. 206-45.19.) A display package for stick candy.

2,582,496. Deinking and bleaching of paper. Peter J. Massey and Frederic C. Goodwill, assignors to St. Regis Paper Co., New York, N. Y. Filed Oct. 9, 1947. 4 claims. (Cl. 92-1.5.) The deinking agent is a mixture of sodium peroxide and sodium silicate.

2,582,541 Shock resistant container. John K. M. Harrison Gainesville, Va. Filed June 24, 1947. 8 claims. (Cl. 229-5.5.) A container for oils or foodstuffs has a multiple end structure—a laminated parchment closure disk, a rigid closure disk, and a rigid waterproof cover disk.

2,582,548. Portable logging tower. Harry D. Larson, assignor to Isaacson Iron Works, Seattle, Wash. Filed April 1, 1946. 2 claims. (Cl. 189-11.)

2,582,792. Process for treating waste liquor from paper. Per Paren, assignor to Jonkopings Mekaniska Werkstas Atkiebolag, Jonkoping, Sweden. Filed Dec. 2, 1946. 1 claim. (Cl. 23-48.) The liquor is sprayed vertically upward into the furnace space in such a manner that the liquor does not reach the walls or bottom of the furnace before being evaporated to a dry or nearly dry condition.

2,582,820. Web unrolling apparatus. Charles A. Dickhaut, assignor to John Waldron Corp., New Brunswick, N. J. Filed Feb. 10, 1947. 4 claims. (Cl. 242-58.) An unwinding device with simultaneous feeding of the web to a treating operation, such as a coating process.

2,582,833. Method for the preparation of aluminum and magnesium soaps. James V. Hunn, assignor to The Sherwin-Williams Co., Cleveland, Ohio. Filed July 12, 1950. 14 claims. (Cl. 260-97.5.) Aliphatic acids (e.g., tall oil acids) are heated with

the metal in an aliphatic alcohol containing a trace of a soluble mercury compound.

2,582,840. Sizing fibrous materials with modified urea-formaldehyde resin. Charles S. Maxwell, assignor to American Cyanamid Co., New York, N. Y. Filed Sept. 7, 1946. 4 claims. (Cl. 92-21.) A wet-strength paper (e.g., 25% kraft and 75% asbestos fibers) is formed with a partially polymerized, hydrophilic urea formaldehyde-sulphite resin colloid.

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2,583,145. Chemical feeder for black liquor recovery systems. Frank W. Hochmuth, assignor to Combustion Engineering-Superheater, Inc., New York, N. Y. Filed Oct. 15, 1947. 3 claims. (Cl. 23-262.) A black liquor recovery system incorporates a vibrating screen mechanism for feeding salt cake into the mixing tank.

2,583,211. Container for liquids. William M. Fleming, assignor to Eskimo Pie Corp., Bloomfield, N. J. Filed Jan. 26, 1949. 2 claims. (Cl. 229-7.) A closure for paperboard milk containers.

2,583,220. Process of leveling and drying coatings with steam. Francis W Lanigan, assignor to Dewey and Almy Chemical Co., North Cambridge, Mass. Filed Dec. 24, 1948. 4 claims. (Cl. 117-64.) The superheated steam is delivered at a velocity of 1000 to 3000 feet per second and at a rate of 100 to 290 pounds per hour per 0.072 square inch of slit orifice area.

2,583,249. Apparatus for manufacturing boards of compressed cellulose material and the like. Merle W. Baker, Forrest F. Beil, Charles F. Curtis II, and Edward A. Patton, assignors to Curtis Co., Inc., Clinton, Iowa. Filed Nov. 13, 1948. 2 claims. (Cl. 18-16.)

2,583,274. Process for producing mineral-coated paper. George E. Niles, assignor to Monsanto Chemical Co., St. Louis, Mo. Filed April 30, 1947. 6 claims. (Cl. 117-155.) The binder consists of a copolymer of 33–65% styrene and 35–67% ethyl acrylate.

2,583,443. Pallet for handling materials. Walter M. Perry, Darien, and Fairfield S. Perry, New Canaan, Conn. Filed Dec. 4, 1947. 8 claims. (Cl. 248-120.) The construction of an expandable pallet is described.

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2,583,548. Production of pigmented cellulosic pulp. William L. Craig, assignor to R. T. Vanderbilt Co., Inc., New York, N. Y. Filed March 17, 1948. 3 claims. (Cl. 106-204.) A 1% suspension of pulp in a solution containing 5 to 10% calcium chloride, after beating, is treated with sodium carbonate, precipitating calcium carbonate onto the fibers.

2,583,641. Boxmaking machine. Rene J. Gaubert and Stanley Marvin, Oakland, Calif., assignors to Simplex Packaging Machinery, Inc. Filed Dec. 3, 1946. 5 claims. (Cl. 93-51.) A method for sealing a formed container.

2,583,672. Carton. Alvin B. Storey, assignor to Celanese Corp. of America, New York, N. Y. Filed April 7, 1949. 1 claim. (Cl. 229-40.) A corrugated board container for conical spools of yarn.

2,583,673. Carton. Alvin B. Storey, assignor to Celanese Corp. of America, New York, N. Y. Filed May 26, 1949. 1 claim. (Cl. 229-40.) This is similar to the above patent.

2,583,712. Folding machine. Albert F. Shields, assignor to S & S Corrugated Paper Machinery Co., Inc., Brooklyn, N. Y. Filed Sept. 11, 1946. 11 claims. (Cl. 93-49.) A machine for forming flat, collapsed, tubular box blanks from flat scored sheets.

2,583,713. Feeding mechanism for folding machines. Albert F. Shields, assignor to S & S Corrugated Paper Machinery Co., Inc., Brooklyn, N. Y. Filed Jan. 3, 1949. 1 claim. (Cl. 271-44.)

2,538,856. Lined dispensing carton. Charles G. Klein, La Junta, Colo. Filed April 6, 1948. 3 claims. (Cl. 229-17.) A wax-sealed carton for powdered material incorporates an integral pouring spout which is also a part of the end closure.

2,583,860. Machine for folding cartons. David Levkoff, Great Neck, N. Y. Filed Sept. 16, 1948. 8 claims. (Cl. 93-49.)

2,583,915. Collapsible box. James E. Whitley, assignor to Mabelle L. Dier, West Vancouver, B. C., Canada. Filed June 30, 1948. 1 claim. (Cl. 229-22.) A collapsible triangular container for pies and the like.

2,583,994. Wood digestion. Ben T. Briggs, assignor to Rayonier, Inc., Shelton, Wash. Filed June 21, 1946. 2 claims. (Cl. 92-13.) Wood is steamed at 140 to 200°C. in the absence of any free liquid and then digested with alkali.

2,584,002. Method and apparatus for bonding closure materials. William F. Elser and Kenneth L. Richard, assignor to Owens-Illinois Glass Co., Toledo, Ohio. Filed Nov. 28, 1950. 11 claims. (Cl. 154-37.) A wax-coated paper closure liné is faced with glassine, cellophane, saran, or a metal foil.

2,584,041. Process for preparing oil-soluble metal soaps. Milton Nowak and Alfred Fischer, assignors to Nuodex Products Co., Inc., Elizabeth, N. J. Filed July 6, 1949. 17 claims. (Cl. 260-97.5.) A fusion process for preparing salts from a powdered metal and an organic acid in water.

2,548,095. Tubular container. Charles E. Slaughter, assignor to Extruded Plastics, Inc., Norwalk, Conn. Filed June 13, 1946. 2 claims. (Cl. 229-5.8.) Method of sealing the end of a thermoplastic tube to produce a container.

February 5, 1952

2,584,247. Pulp screen flow pipe. Emitt S. Anderson and Archie B. Haley, assignors to Minnesota and Ontario Paper Co., Minneapolis, Minn. Filed June 4, 1948. 3 claims. (Cl. 92-29.) A series of conduits is provided for delivering pulp under pressure to a rotary screen It is designed to eliminate slime.

2,584,300. Liquid binder. Charles D. Simmers, assignor to Johns-Manville Corp., New York, N. Y. Filed Dec. 9, 1948. 2 claims. (Cl. 106-123.) A binder suitable for the manufacture of mineral wool batts contains 55% of the pentaerythritol ester of tall oil, 30% linseed oil, 15% of a pentaerythritol ester of rosin, and 0.6% each of iron and manganese naphthenate.

2,584,336. Container and draw cord combination. Raymond Eisenhardt, Ridgewood, N. J., and Jerome J. Gordon, Winnetka, Ill. Filed Dec. 13, 1949. 2 claims. (Cl. 229-51.) A cardboard container has a nylon draw cord.

2,584,414. Miniature cotton bale receptacle. Pierre E. Bagur, New Orleans, La. Filed March 2, 1950. 2 claims. (Cl. 229-8.) A cardboard box imitates a miniature cotton bale.

2,584,529. Packaging machine. Howard G. Allen, assignor to Savannah Sugar Refining Corp., Savannah, Ga. Filed April 28, 1950. 16 claims. (Cl. 53-148.) Apparatus for closing and securing the ends of a filled bag.

2,584,542. Apparatus for making tubular paper containers. John H. Brown, Jr., assignor to Lily-Tulip Cup Corp., New York, N. Y. Filed April 2, 1947. 18 claims. (Cl. 93-36.1.) An apparatus for the manufacture of two-piece paper cups.

2,584,595. Egg carton. Michael H. Kowal, assignor to Empire Box Corp., Garfield, N. J. Filed Aug. 7, 1946. 2 claims. (Cl. 229-28.) A glued interlocking egg carbon is scored transversely so that it can be divided into two smaller six-egg containers.

2,584,632. Method of making containers. Charles A. Southwick, Jr., assignor to Shellmar Products Corp., Mount Vernon, Ohio. Filed Nov. 9, 1945. 1 claim. (Cl. 154-116.) A duplex paper-polyethylene bag has a filling valve which can be heat sealed after the bag is filled.

2,584,658. Paperboard partitioned article carrier. Edwin L. Arneson, assignor to Morris Paper Mills, Chicago, Ill. Filed Sept. 23, 1949. 2 claims. (Cl. 229-28.) The partitions of a bottle carrier extend to the bottom of the carrier.

2,584,689. Bottle carrier. Thomas W. Foster, assignor to Container Corp. of America, Chicago, Ill. Filed May 28, 1948. 4 claims. (Cl. 229-52.)

2,584,693. Method of making fiber products. George A. Gerard, assignor to Jiffy Manufacturing Co., Hillside, N. J. Filed Sept. 11, 1948. 1 claim. (Cl. 154-29.) The preparation of an insulating pad is described.

2,584,718. Container assembling apparatus. Gustave H. Laabs, assignor to Morris Paper Mills, Chicago, Ill. Filed Oct. 1, 1949. 13 claims. (Cl. 93-55.1.) An apparatus for assembling a cylindrical reinforced container (e.g., for ice cream).

2,584,815. Power-operated hydraulic sealer and crimper. Leroy L. Salfisberg, assignor to Ivers-Lee Co., Newark, N. J. Filed June 26, 1948. 14 claims. (Cl. 154-42.) The initial pressing, sealing, or crimping operation is carried out at a low pressure and completed at a higher pressure.

2,584,848. Adhesive applying means for coating the flaps of cartons. Harold Daum and Daniel L. Rugen, assignors to Johns-Manville Corp., New York, N. Y. Filed May 1, 1948. 4 claims. (Cl. 118-223.) A carton sealer is described which can be used with cartons of various sizes without adjustment.

2,584,855. Box blank folding machine. Walter P. Fergnani, assignor to Post Machinery Co., Beverly, Mass. Filed June 26, 1948. 10 claims. (Cl. 93-40).

2,584,925. Machine for closing cartons. Arthur E. Rideout, Chicago, Ill., assignor to Emhart Manufacturing Co. Filed June 9, 1948. 9 claims. (Cl. 53-140.) A mechanism for automatic closing and sealing corrugated containers for bottled beverages.

2,584,967. Packaging tray. Nathan J. Watson, assignor to Chicago Carton Co., Chicago, Ill. Filed Aug. 26, 1949. 9 claims. (Cl. 229-42.) A tray for bakery products is enclosed in a transparent wrapper.

February 12, 1952

223,462. Asphalt emulsion for treatment of coal and method of preparing the same. Charles R. Rosencranse, assignor of 50% to Joe F. Klaner, Jr., Pittsburgh, Kan. Original No. 2,-

431,891, dated Dec. 2, 1947. Application for reissue Aug. 17, 1950. 6 claims. (Cl. 252-311.5.) Tall oil is one of the components.

2,585,031. Machine for electrically sealing fiber containers. Harold T. Odquist and Eugene W. Macoy, assignors to American Can Co., New York, N. Y. Filed May 26, 1947. 3 Claims. (Cl. 93-55.1.) The adhesive is dielectrically heated prior to the bonding of the interfolded parts of the cover.

2,585,049. Pulp molding die. Ernest L. Shepard, assignor to The Canal National Bank of Portland and William B. Nulty, Portland, Me., as trustees. Filed May 19, 1949. 7 claims. (Cl. 92-54.)

2,585,056. Box for displaying contents. Marcus M. Tierney, St. Paul, Minn. Filed Aug. 19, 1946. 13 claims. (Cl. 229-17.) A display container for small hardware articles.

2,585,074. Carton setup machine. Lawrence E. Arneson, assignor to Morris Paper Mills, Chicago, Ill. Filed July 12, 1947. 12 claims. Cl. 93-53.)

2,585,076. Box blank handling machine. James Bandura, Raymond J. Baisley, Joseph Pfeffer, and Clifford D. Keely, assignors to General Corrugated Machine Co., Inc., Palisades Park, N. J. Filed Feb. 14, 1943. 1 claim. (Cl. 214-6.) A machine for stacking and delivering box blanks.

2,585,197. Oil-free wrinkle finish coating. Richard K. Walton, assignor to Union Carbide and Carbon Corp., New York, N. Y. Filed April 14, 1950. 6 claims. (Cl. 260-44.) The resin is a condensation product of phenol, formaldehyde, and a secondary amine.

2,585,201. Carton setup machine. Justin J. Wetzler, assignor to Shellmar Products Corp., Chicago, Ill. Filed May 7, 1948. 10 claims. (Cl. 93-37.) A machine for setting up egg cartons.

2,585,214. Elastic closure fruit bag. Frank Belmont, Anaheim, Calif. Filed July 15, 1949. 4 claims. (Cl. 229-62.)

2,585,226. Winding apparatus. Peter J. Christman, Green Bay, Wis. Filed March 21, 1946. 6 claims. (Cl. 242-56.) A winder includes a mechanism for automatically severing a paper web and transferring the leading end to another core.

2,585,227. Winding apparatus. Peter J. Christman, Green Bay, Wis. Filed March 21, 1946. 4 claims. (Cl. 242-56.) A winder includes means for slitting and perforating a paper web and for automatically severing the web at predetermined intervals.

2,585,336. Quick-breaking bituminous emulsion. Paul E. McCoy, assignor to American Bitumuls & Asphalt Co., San Francisco, Calif. Filed June 14, 1948. 6 claims. (Cl. 252-311.5.) The bitumen is emulsified with up to 10% of a sulphonated tall oil.

2,585,373. Dispensing closure for paper powder containers. Harry K. Dickerman and John N. Brown, assignors to F. N. Burt Co., Buffalo, N. Y., Filed Feb. 14, 1948. 6 claims. (Cl. 222-555.)

2,585,673. Disk chipper with horizontally inclined rotary axes. Peter N. Ottersland, Watertown, N. Y. Filed Sept. 20, 1949. 3 claims. (Cl. 241-92.)

2,585,852. Resilient batt cutting machine. Ray A. Sandberg, assignor to Houdaille-Hershey Corp., Detroit, Mich. Filed Jan. 29, 1948. 11 claims. (Cl. 164-21.) A method of cutting filter units for automotive air cleaners from sisal fiber batts.

2,585,859. Turntable for paper roll stands. Frank W. Showalter, assignor to The American Envelope Co., West Carrollton, Ohio. Filed Oct. 14, 1947. 11 claims. (Cl. 242-64.) A turntable has two series of paper-roll stands.

February 19, 1952

2,585,977. Sulphite liquor treating processes and products. Carl Uschmann, assignor to Cascades Plywood Corp., Portland, Ore. Filed Oct. 13, 1947. 20 claims. (Cl. 260-17.2.) Spent sulphite liquor is concentrated, treated with 5 to 15% alkali. boiled, treated with 5 to 15% furfural, and again heated; the product, with or without phenol, can be used as an adhesive.

2,586,006. Packaging machine. John D. Conti, assignor to American Viscose Corp., Wilmington, Del. Filed June 29, 1949. 23 claims. (Cl. 53-136.) A machine adapted to insert an article into a carton and seal the latter; it is suitable for wound rolls of cellophane or paper.

2,586,014. Dust collector for paper machines. Clifford G. Dunphy, Center Township, St. Joseph County, Ind. Filed June 18, 1947. 5 claims. (Cl. 92-74.) Means for the removal of dust and lint which collect on a doctor blade.

2,586,078. Method and means for packaging. Thomas R. O'Malley, assignor to American Viscose Corp., Wilmington, Del. Filed June 19, 1946. 2 claims. (Cl. 229-87.) A tubular member of pleated permeable sheet material for packaging yarn during liquid treatment.

2,586,156. Paperboard box cover lock. Kenneth C. Ferguson, assignor to Inland Container Corp., Indianapolis, Ind. Filed Jan 7, 1949. 1 claim. (Cl. 229-45.) A cover lock for containers, especially beer cases.

2,586,301. Foldable cardboard bottle carrier. Eli N. Castle, South Orange, N. J. Filed Jan 10, 1950. 5 claims. (Cl. 229-28.) The end walls and transverse partitions are flexible, so that the carrier may be collapsed to a flattened condition.

2,586,345. Electric cable having a nonmigratory insulating compound. Albert King, assignor to British Insulated Callender's Cables Ltd., London, England. Filed Jan. 7, 1946. 7 claims. (Cl. 174-121.) The paper is impregnated with microcrystalline wax modified by polyisobutylene, rosin, or mineral oil.

2,586,514. Method of making carry bags. Leonard E. Canno, assignor to Equitable Paper Bag Co., Inc., Long Island City, N. Y. Filed Dec. 30, 1948. 4 claims. (Cl. 93-35.) The bags are manufactured from a continuous web of glued paper tubing.

2,586,551. Device for setting up collapsible cellular cartons. Edwin H. Mobley, assignor to Bloomer Bros. Co., Newark, N. Y. Filed Aug. 30, 1949. 10 claims. (Cl. 93-37.) A device for egg cartons and the like.

2,586,634. Pulp insulating machine. Waldemar C. Ewaldson and John N. Selvig, assignors to Western Electric Co., Inc., New York, N. Y. Filed April 16, 1947. 6 claims. (Cl. 92-49.) A machine for insulating electrical conductors with pulp.

2,586,726. Method of producing lightweight inorganic insulating material. Clyde C. Schuetz and Charles R. Norman, Jr., assignors to United States Gypsum Co., Chicago, Ill. Filed Feb. 4, 1948. 2 claims. (Cl. 92-55.) The product consists of asbestos fibers and inorganic binder.

2,586,727. Oscillatable bark-removing jet having variable amplitude of oscillation. Ernest C. Shaw, assignor to Allis-Chalmers Manufacturing Co., Milwaukee, Wis. Filed May 22, 1950. 17 claims. (Cl. 144-208.) The amplitude of an oscillating hydraulic jet can be automatically adjusted while the machine is in operation.

2,586,744. Apparatus for cutting and scoring blanks. John S. Troth, assignor to Robert Gair Co., Inc., New York, N. Y. Filed June 29, 1949. 3 claims. (Cl. 93-58.3.) A method of scoring plastic blanks so that the material will not crack along the folding lines.

2,586,765. Dispensing package. Theodore F. Onkey, assignor to Roberts Rouge Co., Stamford, Conn. Filed Jan 29, 1949. 3 claims. (Cl. 206-56.) A dispenser for solid lubricant, polishing compound, and the like.

2,586,767. Method for producing alkylene oxide condensation products. Robert A. Wilson, assignor to Monsanto Chemical Co., St. Louis, Mo. Filed Jan. 31, 1948. 12 claims. (Cl. 260-97.5.) A method of reaction of alkylene oxide and tall oil.

February 26, 1952

2,586,829. Paper machine drier. Walter Kelsey, New York, N. Y. Filed Dec. 8, 1949. 1 claim. (Cl. 34-124.) The drier consists of a lightweight, thin revolving cylinder and an inner stationary cylinder, the two forming an air chamber enclosing heating units.

2,586,886. Display container. Walter J. Tyrseck, assignor to Robertson Paper Box Co., Inc., Montville, Conn. Filed Dec. 3, 1948. 6 claims. (Cl. 229-28.) The container comprises built-in partitions for forming subcompartments, which can be constructed from a single blank.

2,586,903. Mechanism to sever tape between adjacent ends of cartons. Otto A. Badenhausen, Eugene A. Wahl, and Wilhelm Boehl, assignors to P. Ballantine & Sons, Newark, N. J. Filed June 15, 1949. 8 claims. (Cl. 164-48.) A machine for sealing a carton with adhesive tape.

2,587,050. Apparatus for setting-up box blanks. David Levkoff, Great Neck, N. Y. Filed July 3, 1947. 16 claims. (Cl. 93-53.) The machine is designed to set up boxes manufactured according to U. S. pat. 2,342,551 (Feb. 22, 1944).

2,587,064. Method of bleaching wood pulp. William H. Rapson, assignor to Canadian International Paper Co., Montreal, Canada. Filed March 9, 1949. 3 claims. (Cl. 8-105.) Chlorinated and alkali-extracted sulphite or kraft pulp is treated with chlorine dioxide under acid or alkaline conditions and finally bleached with alkaline sodium hypochlorite.

2,587,171. Laminated article having an unimpregnated surface and method of making the same. Norman W. Knewstudd and Colin N. Jenkins, assignors to Union Carbide and Carbon Corp., New York, N. Y. Filed Jan. 7, 1950. 5 claims. (Cl. 154-120.) Fibrous sheets impregnated with a thermosetting resin are laminated during which a single sheet of rough porous paper is included in the pile after which the laminate is split in the plane of the unimpregnated paper sheet.

2,587,266. Water emulsifiable metallic paste pigment. Robert I. Wray and Wayne B. Roberts, assignors to Aluminum Co. of America, Pittsburgh, Pa. Filed Aug. 10, 1948. 11 claims. (Cl. 106-123.) An aluminum paste pigment contains 40 to 78% metal, 15 to 45% tall oil, 4 to 8% casein, and other ingredients.

2,587,267. Water-emulsifiable metallic paste pigments.

Robert I. Wray and Wayne B. Roberts, assignors to Aluminum Co. of America, Pittsburgh, Pa. Filed Nov. 19, 1948. 6 claims. (Cl. 106-123.) This is similar to the above but the mixture contains no casein.

2,587,268. Water-emulsifiable metallic paste pigments. Wayne B. Roberts, assignor to Aluminum Co. of America, Pittsburgh, Pa. Filed Nov. 29, 1949. 7 claims. (Cl. 106-290.) The composition contains tall oil.

2,587,273. Machine for making corrugated paperboard. John Aquilla, assignor to Eagle National Printing and Die Cutting Corp., New York, N. Y. Filed Aug. 8, 1948. 3 claims. (Cl. 154-31.) The invention relates to machines for corrugating paper and applying facings thereto to produce corrugated paperboard and the like.

2,587,422. Machine for the manufacture of paper bags. Stanley C. F. Wills, assignor to E. S. & A. Robinson, Ltd., Bristol, England. Filed May 21, 1949. 2 claims. (Cl. 154-42.) Sealing of paper bags is effected by the application of jets of hot air or other gas.

2,587,497. Vinyl tall oil ester coating compositions. Paul E. Marling, assignor to Monsanto Chemical Co., St. Louis, Mo. Filed July 29, 1948. 8 claims. (Cl. 260-27.) A coating composition is formed by heating vinyl tall oil esters and 0.01 to 5% of anthraquinone in an inert atmosphere.

March 4, 1952

2,587,663. Sealing head mechanism for closing and sealing bags and flexible containers. John E. Socke, assignor to American Can Co., New York N. Y. Filed April 29, 1948. 11 claims. (Cl. 53-102.)

2,587,706. Compartment box partition. Irving A. Deline, Denver, Colo. Filed March 7, 1949. 3 claims. (Cl. 229-15.) In a cut-out partition blank, means are provided for bracing and holding the bent partition in its final position.

2,587,760. Automatic consistency regulator for pulp and paper stocks. Ernest A. Poirier, Waterville, Me. Filed Nov. 8, 1947. 13 claims. (Cl. 137-78.) A method of correcting the consistency of successive portions of a stream of stock.

2,587,808. Bottle carrier. Edwin L. Arneson, assignor to Morris Paper Mills, Chicago, Ill. Filed Jan. 10, 1948. 9 claims. (Cl. 229-28). Improved provisions for reinforcing the handle panel and insuring against tearing of the end wall.

2,587,828. Windowed display container with article supporting platform. Samuel Fogel, Montreal, Canada. Filed April 10, 1946. 7 claims. (Cl. 206-45.19.)

2,587,845. Manufacture of calcium hypochlorite bleach liquor. Harold H. Heller and Robert G. Shirriff, assignors to Paper Patents Co., Neenah, Wis. Filed Oct. 8, 1949. 7 claims. (Cl. 23-86.) Details are given of the reaction of chlorine with calcium hydroxide to form calcium hypochlorite.

2,587,833. Process for splicing paper. Leo M. Germain, assignor to Shawinigan Chemicals Ltd., Montreal, Canada. Filed Nov. 24, 1950. 3 claims. (Cl. 154-116.) A method of splicing paper with a lm of plasticized polyvinyl alcohol-acetate resin.

2,587,909. Molded pulp egg carton. Francis H. Sherman, assignor to Shellmar Products Corp., Chicago, Ill. Filed Feb. 17, 1947. 5 claims. (Cl. 229-2.5.) A method of locking the cover in closed position is provided.

2,587,992. Dry process for agglomerating wood particles. Siegfried Glaubert, Neuilly-sur-Seine, France. Filed Oct. 30, 1948. 3 claims. (Cl. 106-163.) Wood scrap or other lignocellulosic material is mixed with 0.25 to 0.50% of valeric acid (as 22% solution) and then with a similar quantity of sulphurous acid, stirred 1 to 10 minutes at room temperature, and then compressed by heat and pressure.

2,587,999. Manufacture of chalk. Harold H. Heller and George H. Saunders, assignors to Paper Patents Co., Neenah, Wis. Filed June 27, 1950. 8 claims. (Cl. 23-66.) A method of carbonating calcium hydroxide with flue gas to form calcium carbonate suitable for paper coating.

2,588,132. Machine for the manufacture of fiber footwear. Stephen W. Lippitt, assignor to Sani-Tread Co., Inc., Buffalo. N. Y. Filed June 17, 1947. 2 claims. (Cl. 93-1.) A machine for production of paper sandals.

2,588,150. Egg packing material. Arthur W. Nelson and Torris H. Alfreds, assignors to Mapes Consolidated Manufacturing Co., Griffith, Ind. Filed Dec. 7, 1946. 3 claims. (Cl. 217-34.) An interior packaging material for egg cases.

2,588,228. Industrial and papermakers' felt and method of producing the same. Percival T. Gates, assignor to Drycor Felt Co., Belleville, N. J. Filed Jan. 16, 1948. 14 claims. (Cl. 28-72.2.) A method of incorporating nylon or other synthetic fiber into a papermaker's felt.

2,588,232. Shipping case for fragile articles. Jesse R. Grant, Chicago, Ill. Filed Jan. 16, 1948. 4 claims. (Cl. 229-23.) A corrugated board shipping case has ends and partitions of two thicknesses.

2,588,318. Water emulsifiable soil-poison concentrate. Paul G. Benignus, assignor to Monsanto Chemical Co., St. Louis, Mo. Filed Feb. 7, 1949. 2 claims. (Cl. 167-31.) The reaction product of tall oil and ethylene oxide is used in the preparation of a soil poison containing chlorinated aromatic compounds (e.g., biphenyl, benzene).

March 11, 1952

2,588,340. Manufacture of fiber gasket material. John W. Baymiller, assignor to Armstrong Cork Co., Lancaster, Pa. Filed Sept. 20, 1948. 9 claims. (Cl. 117-164.) In the preparation of gasket material, a kraft paper is impregnated with glue 1, resorcinol 0.1, glycerin 3.5, triethanolamine 0.2, and water 8 parts by weight.

2,588,362. Flame retardant polyethylene and lignin containing composition. Robert C. Danison, assignor to Diamond Alkali Co., Cleveland, Ohio. Filed Aug. 17, 1949. 4 claims. (Cl. 260-17.4.) A mixture of polyethylene and lignin (e.g., hydrolyzed wood or redwood bark flour) with a chlorinated paraffin is milled at 215°C.; the product is self-extinguishing and resistant to drip.

2,588,377. Carton. William P. Frankenstein, Cincinnati, Ohio. Filed April 4, 1946. 11 claims. (Cl. 229-33.) The patent covers a knocked-down carton of the "break-back" lid type.

2,588,384. Box or carton stripper machine. Eric L. Hedstrom, Martin C. Otto, and Cecil E. Gooderham, Buffalo, N. Y. Filed Aug. 10, 1946. 12 claims. (Cl. 93-58.) A machine for removal of the waste present after die cutting and creasing boxes.

2,588,409. Package and enclosed tray thereof. Thomas S. Olsen, assignor to General Baking Co., New York, N. Y. Filed March 29, 1949. 2 claims. (Cl. 206-56.) A method of wrapping sliced bread.

2,588,448. Feeding device for wood grinders. Erwin A. Worm, Jr., and Arthur G. Raymond, assignors to Armstrong Cork Co., Lancaster, Pa. Filed May 2, 1949. 7 claims. (Cl. 241-282.) A device adapted to receive a plurality of bolts of wood for simultaneous discharge into the pocket of a wood grinder.

2,588,455. Folding box. Wallace A. Adams, Petaluma, Calif. Filed June 28, 1948. 16 claims. (Cl. 229-34.) A lightweight folding box which can be stacked.

2,588,533. Paper pulp screen plates and support means for the same. Victor Johnson, Providence, R. I. Filed Nov. 29, 1946. 6 claims. (Cl. 92-30.)

2,588,580. Apparatus and method for manufacture of composite web material. Thomas M. Scruggs, assignor to Bemis Bro. Bag Co., St. Louis, Mo. Filed Aug. 7, 1950. 8 claims. (Cl. 154-1.6.) An apparatus for adhesively combining a web of open-mesh fabric and a paper label strip narrower than the web.

2,588,695. Labeled open-mesh bag. Charles V. Brady and August F. Ottinger, assignors to Bemis Bro. Bag Co., St. Louis, Mo. Filed Dec. 4, 1948. 8 claims. (Cl. 150-1.) A method of attaching a water-resistant label to an open-mesh bag.

2,588,727. Disposable dish and base therefor. Kevin E. Howard, Takoma Park, Md. Filed May 4, 1945. 1 claim. (Cl. 65-15.) A liner for a plate is formed of grease- and moisture-resistant paper or board.

2,588,791. Bobbin package. James B. W. Andrew, Jr., assignor to Container Corp. of America, Chicago, Ill. Filed Aug. 14, 1948. 1 claim. (Cl. 206-65.) A paperboard wrap for bobbins.

2,588,808. Oil base fluid for drilling wells. Reginald D. Dawson, assignor to Shell Development Co., San Francisco, Calif. Filed Feb. 14, 1949. 13 claims. (Cl. 252-8.5.) Magnesium tallate is used as emulsifier for a water-in-oil drilling emulsion.

2,588,936. Egg carton. Joseph A. O'Reilly, Bellingham, Wash. Filed Dec. 6, 1949. 6 claims. (Cl. 229-29.) The carton has a succession of spaced, transverse cushioning strips on which the eggs are supported in the cells.

2,588,950. Return envelope. Willard Woolsey, Chicago, Ill. Filed July 12, 1947. 3 claims. (Cl. 229-73.)

2,588,970. Hydraulic fluid compositions. Vito Esposito, assignor to R. M. Hollingshead Corp., Camden, N. J. Filed Oct. 17, 1949. 11 claims. (Cl. 252-79.) A hydraulic fluid composition consists of ethylene glycol and an alkylene oxide-treated tall oil.

2,588,996. Box closure. Robert F. Synder, East Cleveland, Ohio. Filed June 10, 1948. 5 claims. (Cl. 229-17.) The carton top has a trapezoidal flap at one side with the narrow side thereof articulated.

2,589,033. Paper-cutting apparatus. John R. Baumgartner, assignor to Mercury Engineering Corp., Milwaukee, Wis. Filed May 31, 1949. 3 claims. (Cl. 164-59.) A locator for properly positioning a stack of paper sheets prior to cutting.

2,589,045. Tube type container. Lewis C. Brooks, assignor to Ira M. Jones, River Hills, Wis. Filed April 16, 1947. 2

claims. (Cl. 229-37.) A method of forming containers for frozen food products.

2,589,125. Match package. Joseph A. Pastula, Hartford, Conn. Filed Dec. 9, 1949. 1 claim. (Cl. 206-29.)

March 18, 1952

2,589,233. Method of preparing stabilized tall oil nitriles. John Drew and Joe C. Funderburk, assignors to Hercules Powder Co., Wilmington, Del. Filed March 14, 1950. 6 claims. (Cl. 260-97.5.) Tall oil containing a catalytic quantity of the carboxylic acid salt of a metal of Group II at a temperature of 250 to 350°C. is treated with ammonia.

2,589,252. Process for metal recovery. Clark C. Heritage and William G. Van Beckum, assignors to Weyerhaeuser Timber Co., Longview, Wash. Filed Dec. 7, 1946. 9 claims. (Cl. 260-124.) Lignin is used to recover metals from aqueous solutions of low concentrations.

2,589,302. Method of applying a discontinuous coating to paper. Paul A. Snowman, Jr., assignor to North American Paper Process Co., Inc., New York, N. Y. Filed Aug. 5, 1948. 3 claims. (Cl. 117-38.) A method of applying a coating by intaglio means to a traveling web of sheet material.

2,589,379. Process and device for the manufacture of corrugated sheets of asbestos cement. Carl Herzog, assignor to Eternit A.-G., Glarus, Switzerland. Filed Feb. 4, 1949. 7 claims. (Cl. 154-30.)

2,589,502. Laminated sheet for use as a wall or floor covering. Joseph M. Lurie, assignor to Bonafide Mills, Inc., Lisbon, Me. Filed April 14, 1947. 4 claims. (Cl. 154-49.) A thin film of a synthetic resin (e.g., vinyl resin) is laminated to a sheet of hard fiberboard and then adhesively adhered to a felt board, roofing felt, or the like.

2,589.632. Composite mailing enevelope. Harold S. Scott, Alliance, Ohio. Filed Oct. 18, 1950. 4 claims. (Cl. 229-73.)

2,589,638. Paper machinery. Stephen A. Staege, assignor to The Black-Clawson Co., Hamilton, Ohio. Filed July 19, 1946. 11 claims. (Cl. 92-43.) A method for continuous control of the flow conditions of stock approaching the forming member of a paper machine to avoid abrupt changes in velocity or pressure.

2,589,639. Paper machinery. Stephen A. Staege, assignor to The Black-Clawson Co., Hamilton, Ohio. Filed Oct. 17, 1947. 6 claims. (Cl. 92-44.) A stock inlet for a fourdrinier paper machine.

2,589,733. Method of operating film evaporators. Curt F. Rosenblad, assignor to Rosenblad Corp., New York, N. Y. Filed Sept. 11, 1946. 1 claim. (Cl. 183-2.5.) A method which diminishes or eliminates danger of foam in evaporation.

2,589,765. Web carrier and method of making. Orion W. Berglund, assignor to The Orr Felt Blanket Co., Piqua, Ohio. Filed Feb. 17, 1950. 4 claims. (Cl. 28-72.3.) A felt is impregnated with a phenolformaldehyde resin.

2,589,941. Molding compositions from cellulose, formaldehyde, hydrocarbon, and alkali. Emil Hene, assignor to Usewood Corp., New York, N. Y. Filed Aug. 21, 1951. 23 claims. (Cl. 260-9.) A synthetic board is formed from a mixture of yellow pine sawdust, a hydrocarbon boiling at 725 to 743°F., a phenol, formaldehyde, and sodium hydroxide.

2,589,944. Machine for prebreaking, gluing, folding, delivering, and stacking creased carton blanks. Harold S. Labombarde, assignor to The International Paper Box Machine Co., Nashua, N. H. Filed April 2, 1948. 34 claims. (Cl. 93-52.)

2,589,966. Adhesive applicator for corrugating machines. Gabriel N. Rullo, assignor to S & S Corrugated Paper Machinery Co., Inc., Brooklyn, N. Y. Filed Jan. 15, 1948. 1 claim. (Cl. 118-249.)

2,590,013. Plasterboard, scuff resistant paper liner, and process. Harry N. Huntzicker and John K. Wise, assignor to United States Gypsum Co., Chicago, Ill. Filed June 22, 1948. 6 claims. (Cl. 154-45.9.) A porous sheet having scuff-resistant properties useful in the manufacture of paper-lined gypsum board.

2,590,032. Laminated covering and process of making same. Robert K. Petry, assignor to Congoleum-Nairn Inc., Kearny, N. J. Filed March 4, 1947. 4 claims. (Cl. 154-26.) A covering for floor and wall coverings is formed from a vinyl film with a filler of asbestos fiber, wood flour, silica flour, limestone, and other materials.

March 25, 1952

2,590,273. Envelope with hanger support. Seymour Robins, New York, N. Y. Filed May 15, 1950. 4 claims. (Cl. 229-68.) A mailing envelope with a flexible hanger or cord.

2,590,288. Cylinder type paper machine. Roy H. Breyfogle and Robert F. Hollis, assignors to Alton Box Board Co., Alton, Ill. Filed April 19, 1947. 7 claims. (Cl. 92-43.) A seal assembly for a cylinder type paper machine by means of which the cylinder mold is easily removed.

2,590,371. Knockdown box. Robert M. Bergstein, Cincinnati, Ohio. Filed April 2, 1947. 3 claims. (Cl. 229-32.) A box is prepared from nonscorable sheeting.

2.590,568. Sleeve for bag valves. Harry Peters and Clyde D. Pierson, assignors to The Raymond Bag Co., Middletown, Ohio. Filed May 27, 1949. 2 claims. (Cl. 229-62.5.) A slit sleeve that can be firmly engaged by and supported on the inserting element during the folding and inserting operations.

2,590,570. Preparation of stabilized tall oil nitriles. Stearns T. Putnam, assignor to Hercules Powder Co., Wilmington, Del. Filed March 7, 1950. 7 claims. (Cl. 260-97.5.) A hydrogenated or dehydrogenated tall oil is treated with ammonia to form a nitrile.

2,590,571. Preparation of stabilized tall oil amines. Stearns T. Putnam, assignor to Hercules Powder Co., Wilmington, Del. Filed March 7, 1950. 8 claims. (Cl. 260-97.5.) A stabilized tall oil nitrile (previous patent) is reduced over Raney nickel catalyst to form the amine.

2,590,653. Tall oil modified alkyd resins and process for preparing the same. Alfred F. Schmutzler, assignor to American Cyanamid Co., New York, N. Y. Filed April 16, 1949. 24 claims. (Cl. 260-22.) Tall oil and maleic anhydride are heated with zinc dust, esterified with pentaerythritol, and the product reacted with acrylonitrile and/or styrene.

2,590,654. Printing inks from tall oil modified alkyd resins. Alfred F. Schmutzler, assignor to American Cyanamid Co., New York, N. Y. Filed April 16, 1949. 9 claims. (Cl. 260-22.) The tall oil modified alkyd resin prepared according to U. S. pat. 2,590,653 is the basis of a printing ink vehicle.

2,590,655. Modified tall oil esters and process of preparing the same. Alfred F. Schmutzler, assignor to American Cyanamid Co., New York, N. Y. Filed Aug. 15, 1950. 15 claims. (Cl. 260-23.) Tall oil is esterified with a standard aliphatic polyhydric alcohol and the product is reacted with acrylonitrile and/or styrene.

2,590,724. Insulated box. James Ruthven, Jr., Rockland, and Robert G. Harrison, North Quincy, Mass. Filed Oct. 11, 1949. 3 claims. (Cl. 229-16.) The construction of a double-walled insulated case for beverages.

2,590,774. Box cutting attachment for paper box machines. Harry Keller, Philadelphia, Pa. Filed March 16, 1950. 9 claims. (Cl. 164-61.) An attachment for making one or more cuts, slits, or scorings in the side walls or the end walls of a paper box.

Instrumentation Studies. LXXI. Methods of Measuring the Moisture Content of Paper

A Study of the Effect of Moisture Content on the Electrical Resistance of Paper and an Evaluation of the Hart Moisture Meter and the Moisture Register

K. W. HARDACKER and R. D. RAWCLIFFE

A study has been made of the reliability of the Hart Moisture Meter and the Moisture Register as instruments for measuring the moisture content of paper. In addition, a general investigation of the variation of the electrical resistance of paper with moisture content has been carried out. Measurements were made to determine the effect on the resistance-moisture characteristic of variations in fiber furnish, beating, pH, dyes, size, density, basis weight, and ash content of the sheet. The effects of most of these variables were large enough to make it necessary to obtain a separate Hart Meter or Moisture Register calibration curve for each sheet.

THE moisture content of paper is a quantity of considerable interest both to the manufacturer and to the user. The physical properties of paper are profoundly affected by its moisture content. Among the more important properties affected might be mentioned strength, basis weight, tendency to curl, electrical resistance, and dielectric properties. A change in the moisture content causes a change in the dimensions of the sheet, much to the annoyance of the printer.

A great deal of effort has gone into the development of instruments and methods for measuring moisture content. A number of these might be called fundamental in that a direct measurement is made of the amount of moisture contained in the sheet whereas, in another class of methods, the moisture content is determined indirectly by its effect upon other properties of the paper—for instance, its electrical resistance. Any instrument which uses one of these "secondary" methods must be calibrated by means of measurements of a fundamental type, and the accuracy which these instruments can attain is limited, of course, by the accuracy of this calibration. Occasionally, secondary instruments are produced whose precision is superior to that of the fundamental method by which they were calibrated, and their manufacturers are prone to claim greater accuracy for them, forgetting that, at best, their accuracy can only be equal to that of the fundamental calibration. West (*1*) has prepared an extensive bibliography of these methods and instruments which should be consulted by the interested reader.

The oven method (*2*, *3*) is the most straightforward of the fundamental methods for the determination of moisture. The sample of paper is weighed, dried thoroughly in an oven, and reweighed. The loss of weight is assumed to result from the evaporation of moisture from the sheet, so that the percentage moisture content can be found from the weights by simple arithmetic. The method is not quite as simple as it seems, and care must be exercised to obtain good results. Because of the extremely hygroscopic nature of cellulose, for instance, the dried sheet must be enclosed to prevent absorption of moisture while weighing. The drying should not be continued too long, as the fibers tend to decompose. Papers containing other volatile material—for instance, waxed papers—cannot be measured by this method. In the hands of an experienced technician, the measurements should be reproducible to within 0.2% moisture content.

In the distillation methods (*4*, *5*), the water is distilled from the paper with a solvent immiscible with water—such as xylene, toluene, or tetrachlorethylene—into a suitable trap and the volume is measured. Reliable results are obtained when volatile water-soluble substances are absent—for example, the method is suitable for materials containing volatile oils but not for those containing water-soluble alcohols.

Titration methods, such as those based on the reaction of water with acetic anhydride (*6*) and with Karl Fischer reagent (*7–9*), appear most promising in the presence of volatile materials. The latter is especially to be recommended. The method gives the same results as the oven-drying procedure for paper containing no volatile substances and gives reliable results when volatile matter is present.

There is a wide variety of instruments of the secondary type, some of these being designed as control devices for use on the web of the machine, and others being more of the nature of laboratory instruments. The former of these will not concern us in this report, but the interested reader may refer to the bibliography by West (*10*) for references. Some of the most useful of the latter class depend for their action upon the electrical properties of the sheet. As water has a dielectric constant of about 80, whereas the air which it replaces in the sheet has a constant of unity, a moist sheet has a higher effective dielectric constant than a dry one. Thus, if the sheet is placed between the plates of a condenser, the capacity of that condenser is a measure of the moisture content. Several instruments (*11–14*) have been constructed which measure

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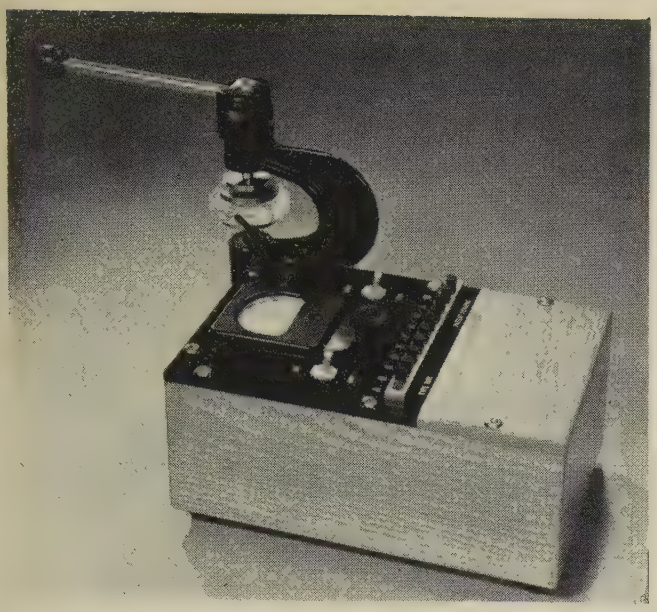


Fig. 1. Hart Moisture Meter

this capacity in various ways. The high-frequency losses of the paper dielectric in the condenser increase, or the Q decreases, as the moisture content increases, and at least one instrument (*15*) has been constructed which measures these losses to determine the moisture content. This increase in loss is primarily due to the fact that the electrical resistance of the paper decreases rapidly with increasing moisture content. Another instrument (*16*), which is basically a resistance meter calibrated to read in percentage moisture content, takes advantage of this fact.

Inasmuch as these electrical methods are relatively new in this field, it was thought worthwhile to investigate the general electrical properties of paper as they are affected by moisture contents in the range of about 3 to 10%, which includes the moisture contents usually encountered and, in particular, to determine the reliability of two of these instruments, the Hart Moisture Meter (*16*) and the Moisture Register (*15*), about which a number of inquiries had been made. These meters were kindly made available by their manufacturers (*17*) for these tests.

A program was set up in which two laboratory resistance meters were constructed to study the resistance-moisture properties of paper. Then a rather thorough comparison was made between the measurements made on a variety of paper types at several moisture contents with these two laboratory instruments and with the Hart Moisture Meter and the Moisture Register.

This range of moisture contents (3 to 10%) has been the subject of only a small amount of investigation (*18, 19*), although a great deal of work has been done on the electrical properties of paper at very low moisture contents, such as those required for condenser tissue. Recent work in this field at the Institute has been reported by Delevanti and Hansen (*20*), Calkins (*21*), and Verseput (*22*).

THE HART MOISTURE METER

The Hart Moisture Meter is shown in Fig. 1. The "contactor" in which the paper sample is held may be seen in the upper left portion of the cut. The paper is placed between the two polished metal electrodes and the arm is pulled down, actuating a cam mechanism which subjects the paper to a pressure of about 120 p.s.i. From the electrical circuit (Fig. 2) it is seen that the instrument is a vacuum-tube voltmeter, arranged to compare the resistance of the sheet with that of a "standard" resistance mounted within the cabinet. A series of ten such standard resistances is provided, any one of which may be placed in the circuit by pushing the appropriate push button (A through M). The operation of the instrument is as follows: the paper is placed in the contactor and the microammeter is brought to zero reading (mid-scale) by adjusting the resistor R_4. The paper is then removed, and various push buttons are tried until two adjacent ones are found such that one gives a positive and the other a negative deflection of the meter. These resistances, then, bracket the resistance of the paper. The push-button resistances are calibrated in terms of the corresponding moisture contents for the particular grade of paper being measured. The standard resistors have been so chosen that the curve of push-button number versus moisture content is very close to a straight line for this paper. For other grades of paper, a new calibration curve is needed, which may or may not be a straight line.

From the circuit diagram it is seen that paper (or the standard resistor) is connected in a voltage-dividing circuit between plus and minus 45 volts, the elements of this voltage divider being the paper and the resistors R_1, R_2, and R_3. As the last three resistances are fixed, the voltage on the grid of the tube and, hence, also the plate current through the tube are determined by the paper (or standard) resistance. Part of this plate current flows through the microammeter. For the four buttons, A, B, C, and D, the voltage-divider circuit is changed, the resistors R_1 and R_2 being eliminated. This change makes it unnecessary to use standard resistors in these positions of as high resistance as would otherwise be needed, thus simplifying the insulation problem. The filament battery also furnishes current to the microammeter through the resistance R_4. As this current passes in the opposite direction to the plate current, the net deflection of the meter is due to the difference between these two currents. The resistor R_5 is connected so that it may be used as a

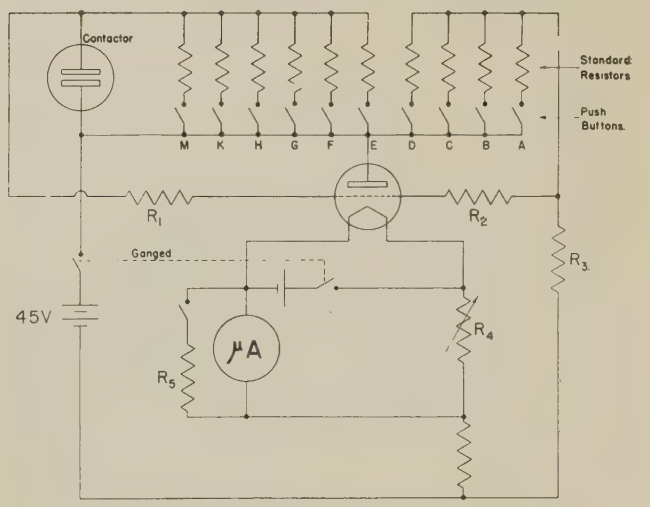


Fig. 2. Simplified schematic of Hart Moisture Meter

shunt across the meter, thus providing high and low sensitivity ranges. The higher sensitivity range was used exclusively throughout this investigation.

The Hart meter applies a direct voltage across the paper, the magnitude of which depends upon the resistance of the paper, and varies from about 1 volt to nearly 45 volts. It is known that the resistance of the sheet depends upon the voltage applied and, also, that when a direct voltage is used, polarization effects within the paper become important. In order to determine the importance of these effects, two laboratory instruments were constructed: a vacuum-tube voltmeter and an alternating current bridge, in both of which the voltage across the paper could be kept constant. For each of these, the contactor from the Hart meter was utilized to hold the paper sample, in order to standardize the clamping conditions.

THE DIRECT CURRENT VACUUM-TUBE VOLTMETER

The direct current vacuum-tube voltmeter circuit is shown in Fig. 3. The voltmeter proper is a two-stage d.c. amplifier consisting of type 31 and type 33 tubes and the components to the right in the figure. Current from the 3-volt filament battery passes through the variable resistance R_5 and through the galvanometer, G, in the reverse direction to the plate current of the type 33 tube, thus "bucking out" the steady portion of the plate current so that small variations of this current may be read on a sensitive meter. Several shunts are provided so that the circuit may be brought to approximate balance without damaging the galvanometer. This resistance (R_5) is adjusted so that the galvanometer reads zero when the first grid is open circuited. The grid then assumes a slightly negative potential, determined by the tendency of the tube to have a slight amount of grid current. The grid circuit of this tube is the most critical area on the instrument. When very high resistances were measured, the meter showed instability which was traced to leakage in this circuit. This leakage was of two forms: leakage through the base, socket, and connections to this grid, and grid current proper within the tube. For very high resistance measurements, this leakage became more important than the conduction current through the resistances being measured; thus, the potential assumed by the grid was not determined by these resistances, and the calculated resistance values were greatly in error. The grid current was greatly reduced by decreasing the plate voltage from the original 45 volts to 3 volts. This considerably reduced the gain of the amplifier, so that it was necessary to use a more sensitive galvanometer than had originally been planned. A further improvement was obtained by selecting the tube with the lowest grid current, cracking off the base, and mounting this tube by its lead wires. All other grid circuit wiring was carefully insulated to minimize leakage.

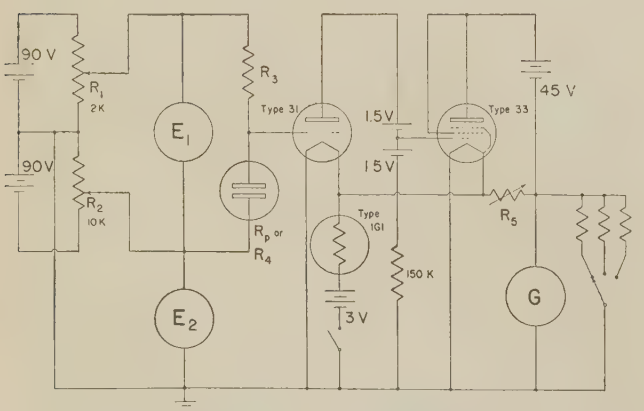


Fig. 3. D.c. vacuum-tube voltmeter circuit

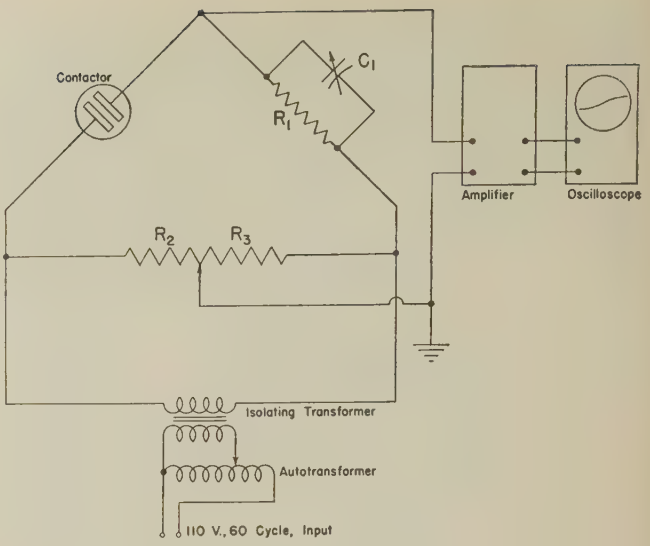


Fig. 4. A.c. bridge circuit

The circuit to the left of this tube is arranged to apply a constant voltage to the paper. Voltages up to 90 volts (plus and minus) are available on the sliders of the potentiometers R_1 and R_2—the total voltage between these sliders being applied across the standard resistor R_3 and the contactor (from the Hart meter) in series. This total voltage, E_1, is measured by the voltmeter E_1; the negative part of the voltage, E_2, is measured by the voltmeter E_2. With E_2 set at any convenient operating point, the voltage E_1 is adjusted until the galvanometer, G, shows zero deflection, so that the first grid is returned to its "open circuit" potential. If E_p is the voltage across the paper, then

$$E_p = E_1 R_p/(R_3 + R_p)$$

where R_p is the resistance of the paper. The paper and contactor are then replaced by a second standard resistor and, with the voltage, E_2, maintained at its original value, E_1 is readjusted until the galvanometer again reads zero. If we call this new voltage E_1' and the new standard resistor R_4, then

$$E_p = E_1' R_4/(R_3 + R_4)$$

But these two values of E_p must be the same and, therefore, the two right members of the equations may be set equal to each other and the resultant equation solved for R_p, giving

$$R_p = \frac{E_1' R_3 R_4}{E_1(R_3 + R_4) - E_1' R_4}$$

The voltage on the paper can be found by solving one of the above equations for E_p. The voltage on the first grid is $E_2 - E_p$.

THE ALTERNATING CURRENT BRIDGE

A simple alternating current bridge was set up as in Fig. 4. Once more, the contactor from the Hart meter

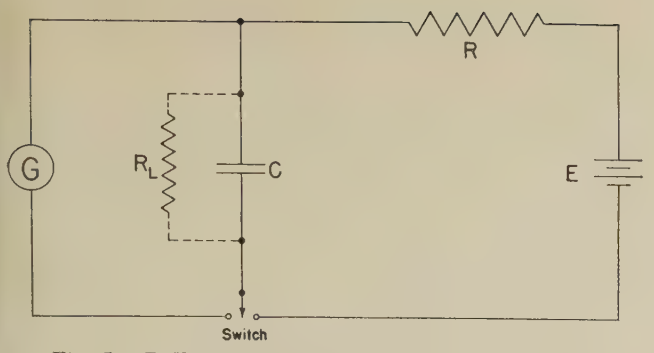


Fig. 5. Ballistic galvanometer circuit for resistor calibration

was used to hold the paper. As the electrodes of this contactor are fairly close together, there is an appreciable capacity between them, and it was necessary to add a variable condenser, C_1, across resistor R_1 in the standard resistance arm in order to obtain a sharp balance. The output signal of the bridge was amplified by a three-stage General Radio type 514-A amplifier and by the internal amplifier of an RCA type TMV-122B cathode ray oscilloscope, and then applied to the vertical deflection plates of the oscilloscope. In this way a very sensitive null indication was obtained. To obtain the balance, the ratio R_2/R_3 of the decade resistance divider and the capacity C_1 were varied. The sensitivity was such that a change of one unit in the third place on the resistance divider was just detectable. At the balance point, the customary bridge equations hold:

$$R_p = R_1R_2/R_3, \text{ and } C_p = C_1R_3/R_2$$

The voltage to the bridge was supplied from the 110-volt, 60-cycle mains. It was adjusted to any desired value by the autotransformer shown. An isolating transformer was necessary to eliminate direct connections from the bridge through the line to ground.

CALIBRATION AND TESTING OF THE DIRECT CURRENT VACUUM-TUBE VOLTMETER, THE ALTERNATING CURRENT BRIDGE, AND THE HART MOISTURE METER

Both the vacuum-tube voltmeter and the bridge involve the use of standard resistances in the range of 10^6 to 10^{11} ohms. As precision resistors in this very high range are not commercially available, it was necessary that a selection of available resistors be measured. This was done by the usual ballistic galvanometer-condenser discharge method, using the circuit shown in Fig. 5. The resistor to be measured is at R, a high quality condenser of known capacity is at C, and a battery of known e.m.f. is at E. The switch was first turned so that the condenser was connected through R to E; it was allowed to stand for t seconds, during which time a charge accumulated on the condenser. The switch was then thrown so as to discharge the condenser through the galvanometer, G, the deflection of G being observed so as to measure the total charge flowing through it. If the voltage to which the condenser charges is small compared with E, the total charge accumulated by the condenser is

$$Q = It = tE/R$$

where I is the current flowing. But

$$Q = kd$$

where d is the deflection of the galvanometer and k is its sensitivity factor, so that

$$R = tE/kd$$

from which the resistance may be calculated.

No condenser is a pure capacitance, but actually has a certain amount of leakage, which may be represented by a resistance, R_L, in parallel with C. This resistance should be large compared with R, so that the leakage current will be small compared with the charging current. This leakage resistance limits the size of the resistance which can be measured by this method. As any leakage in the switch has the same effect as leakage in the condenser itself, it is essential that this switch be arranged to minimize this leakage. In this experiment, a cup containing a small amount of mercury was mounted directly on the condenser terminal, and the leads to the galvanometer and to the battery were fastened to metal hooks mounted on the ends of insulating rods. These rods could be handled without danger of leakage since they were connected to low resistance circuits. With this arrangement, resistances as high as 2×10^{11} ohms could be measured without serious error from leakage.

This circuit did not work well with resistances of the order of 10 megohms or less, as the time (t) required for the accumulation of the charge became so small that it could not easily be controlled. Therefore, a simple direct current bridge was connected for measurement of the resistance in this range.

As a small amount of dirt or moisture on the surface of a very high resistance can seriously change its resistance value, it was necessary to protect these resistors after they had been measured. They were mounted on bolts sealed through a polystyrene sheet, this sheet being sealed on a desiccator. The resistance values were determined after the resistors had been conditioned in this dry atmosphere, and the desiccator was not opened thereafter during the course of the project.

The measurements with the Hart meter depend, of course, upon its group of standard resistances. These are not precision resistors, but are probably selected at the factory by a process of trial and error to make the moisture calibration curve a straight line for a particular grade of paper. This calibration relates the meter reading to the percentage moisture, so that knowledge of the actual resistance is immaterial. As the instrument is fundamentally a resistance measuring

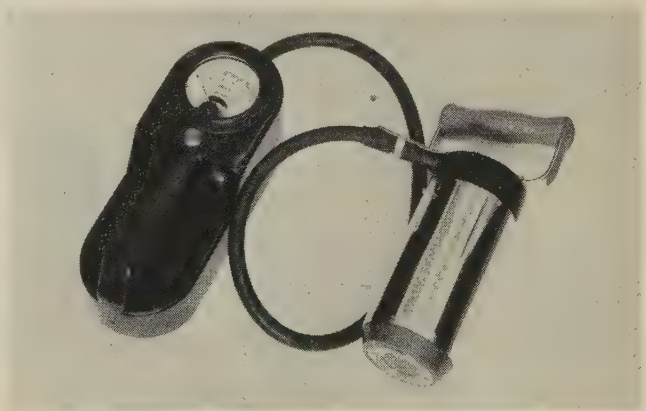


Fig. 6. Moisture Register

Table I. Resistance Measurement with A.C. Bridge
(Values in Megohms)

R	R_1	R_p
117.2	138.0	118.5
	19.75	110.3
	162.5	115.9
162.5	117.2	177.5
	138.0	173.3
	299	175.0
337	162.5	342
	299	354
1,140	162.5	1,060
	337	1,115
	2,920	2,460
2,920	299	1,885
	1,140	1,700
	13,020	10,790
	25,500	18,620
13,020	1,140	7,120
	2,920	12,610
	25,500	60,500

9.7 volts applied to bridge.

device, however, it is essential that its readings of resistance be stable—that is, that a given button will indicate the same resistance today as it indicated 6 months ago. The drift of the instrument over a long period was not determined because of time limitations but, instead, its properties as a resistance meter were investigated, as described below, in order to obtain an indication of the probability of drift. It was necessary, first, to measure the resistance of the standard resistors within the meter, this being done in the same manner as with the other standard resistors. These resistors cannot be protected in a desiccator, but they are protected from dirt, since they are mounted within the meter cabinet.

The next step was to check the accuracy of these instruments by measuring various resistances with them and comparing the values thus obtained with those obtained by the ballistic galvanometer method. With the a.c. bridge (Fig. 4), the best accuracy should be obtained if R_p and R_1 are nearly equal, so that the resistance divider is near its center, but the accuracy should not fall off too seriously if the divider ratio, R_2/R_3, is within a range of about 0.25 to 4. In Table I, measurements are given in megohms for six different resistors; in each case, several different values of R_1 were used. The column headed R_p gives the resistance calculated from the bridge equation and that headed R gives the resistance as measured with the galvanometer circuit. These two should agree, of course, and they do agree within about 10% as long as neither R nor R_1 is much greater than 1000 megohms; beyond that point, however, the agreement

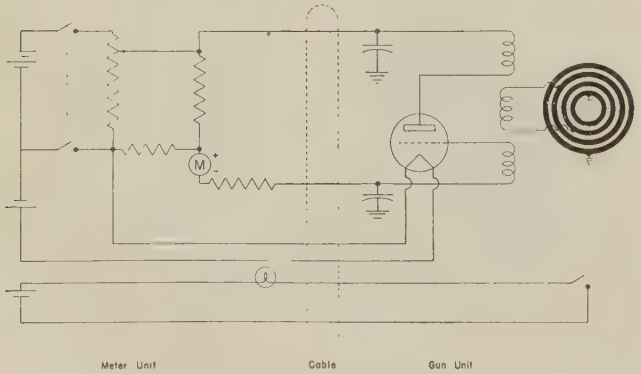


Fig. 7. Simplified schematic of Moisture Register

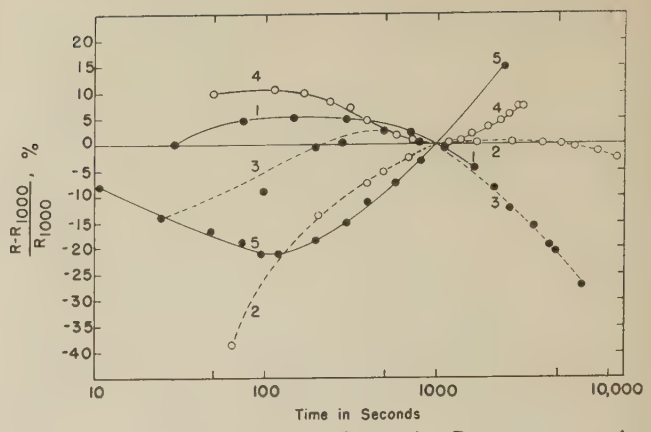


Fig. 8. D.c. measurements; Paper 0. Percentage variation of R from R at 1000 seconds vs. time

Curve	R. H., %	Approx. V_p	R_{1000}
1	32.5	25	1016 meg.
2	39	29	227
3	42	65	138
4	52	25	63.1
5	59	6.3	11.7

between the two measurements is very poor. In the neighborhood of 10,000 megohms, the bridge does not do much more than place the decimal point.

Fortunately, it was not necessary to measure any resistances higher than 1000 megohms with the papers and moisture contents involved. If it had been necessary to measure higher resistances, it is felt that a thorough shielding of the bridge would have extended the range of its reliability. Some improvement is to be expected also from increasing the resistance of the resistance divider to a value more nearly comparable with that of the resistances being measured.

An idea of the reliability of the d.c. meter can be obtained from the data summarized in Table II. To obtain these data, the circuit was balanced with a known resistance, R_4, which was then replaced by an "unknown" whose calculated value is given as R_p, and whose value as measured in the ballistic galvanometer circuit is given as R. All resistances are given in megohms. The resistance R_3 is indicated in the circuit in Fig. 3.

It is seen that the agreement is fair for resistances as high as 10,000 megohms, so that the d.c. voltmeter is definitely superior to the a.c. bridge for higher range resistances.

A similar set of measurements was made with the Hart Moisture Meter; in this case, known resistors were substituted for the contactor, and they were measured as if they were paper. Their resistances were calculated by interpolation between the resistances corresponding to the buttons which bracketed the reading on the measured resistor. The calculation assumed that

Table II. Resistance Measurements with D.C. Vacuum-Tube Voltmeter
(Values in Megohms)

R_3	R_4	R_p	R
299	117.2	141.7	138
299	117.2	170	162.5
299	117.2	1,481	1,140
337	299	160.2	162.5
337	299	1,118	1,140
337	299	2,560	2,920
2920	1140	10,980	13,020
2920	1140	22,500	29,500

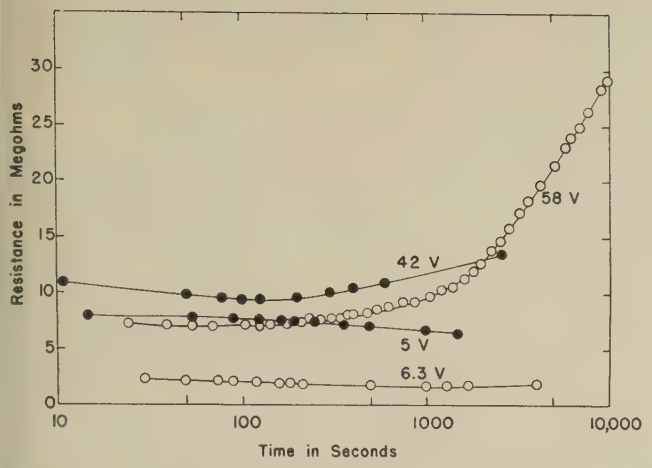


Fig. 9. D.c. resistance of Paper 0 conditioned at 59% R. H. vs. time. The approximate voltages applied to the paper are indicated on the curves

the response of the vacuum-tube voltmeter was linear in the region covered by these resistors. The data obtained are presented in Table III, the resistances again being given in megohms.

From the data, it is evident that the Hart meter is not an accurate resistance meter for the higher resistances. The error in the measurement of the small resistances is partly due to the form which the calculations take, the calculated resistance being the small difference between two large quantities. It should be kept in mind that the calibration of the instrument is against moisture content and not against resistance—the resistance values not being used in practice. If the resistance measurements at one moisture content are consistently low by 50%, for instance, this error is canceled out by the use of a moisture-calibration curve. However, if the resistance measurement varies considerably (if, for instance, there is a slow drift in this reading), then the instrument will require frequent recalibration if its accuracy is to be maintained. It was hoped that, from these checks on the accuracy of the instrument as a resistance meter, some idea of its stability could be obtained. The error in the readings of the higher resistances is probably due to the same kinds of leakage which caused trouble in the d.c. meter. The stability of such leakage is subject to question. The grid current, for instance, depends upon the condition of the tube. Leakage across the external connections depends upon the amount of dirt collected on the insulating members. The error in the resistance measurement is less than a factor of two, however, and variations of this error resulting from drift should be less than this. For the papers tested, a change in moisture content of 1% is accompanied by about a 10-fold resistance change, so that the error caused by drift in the resistance measurement will not introduce any large error in the moisture content determination.

Table III. Resistance Measurements with the Hart Moisture Meter
(Values in Megohms)

R, Galvanometer	*R, Hart meter*
2.89	3.1
8.74	8.5
19.75	20.4
117.2	110
138	135
162.5	161
299	247
337	273
1,140	486
2,920	1,370
13,020	8,610
25,500	18,000
29,500	23,300
53,400	34,600

THE MOISTURE REGISTER

A photograph of the Moisture Register is shown in Fig. 6 and the circuit diagram is shown in Fig. 7. It is seen that the instrument consists of two units connected by a flexible rubber-covered cable. The contactor, which is pressed against the paper, is mounted on the end of the first unit, called the "gun." Within the gun are situated a radio-frequency oscillator tube and its accessory circuit components, a spring arrangement for applying pressure to the paper, and a microswitch which closes when the proper pressure is applied. Power for the gun is supplied through the cable from the battery and meter unit. Within this latter unit are located plate and filament batteries for the oscillator, a push-button switch for these batteries, batteries for a small lamp which lights up when the microswitch is closed, a microammeter, a potentiometer for zeroing the microammeter, and various accessory resistors.

The operation of the instrument is as follows: the gun is held away from any absorbing materials, and a push button is held in, which closes the two battery switches. After the oscillator has warmed up, the potentiometer is adjusted until the microammeter reads zero (full-scale deflection). The gun is then pressed against a pad of the paper whose moisture content is desired, the pressure being increased until the lamp lights, and a reading is taken on the microammeter. From a calibration curve, the microammeter reading may be transformed to a moisture content determination.

This microammeter is connected in the circuit so that it measures the current drawn by the grid of the oscillator tube. This grid current depends upon the amplitude of the oscillation which, in turn, depends

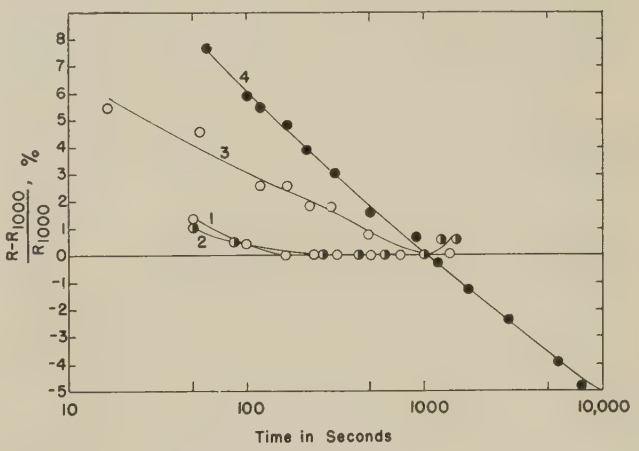


Fig. 10. A.c. measurements; Paper 0. Percentage variation of R *from* R *at 1000 seconds vs. time*

Curve	R. H., %	V_b	R_{1000}
1	32.5	9.7 volts	90.1 meg.
2	42	9.4	38.2
3	52	9.9	19.5
4	59	9.0	6.25

upon the losses of the tuned circuit. The contactor is coupled to this tuned circuit and acts as a condenser, part of whose dielectric is the paper. Dielectric losses in the paper decrease the amplitude of the oscillation and the magnitude of the grid current. As these losses increase with the moisture content of the paper, the grid current becomes a measure of the moisture content. The grid current is also affected by the plate and grid voltages, and the potentiometer which adjusts these voltages, is a "zero adjustment," which is used to correct for changes in battery voltages, tube characteristics, etc.

The operating frequency of the particular unit studied was 10.4 megacycles when there was no paper against the contactor. If the pad of paper measured was such that the grid current dropped to about half its original value, the frequency was reduced to about 8.4 megacycles. If the grid current is decreased to zero, the circuit stops oscillating.

The extent of the field about the contactor is limited by a pair of guard rings around the electrodes, so that it penetrates only a small distance into the paper. The instrument is usually calibrated with a pad of paper thick enough that additional sheets do not change the reading. For this particular model, a pad $^1/_8$ inch in thickness is recommended by the manufacturer.

EXPLORATORY MEASUREMENTS IN SMALL CABINET

For the next phase of the work—that of exploring the general behavior of paper under different humidities—a supply of bleached sulphite handsheets (described more fully later) was made under controlled conditions by the Institute's pulping laboratory. This paper was chosen as a representative type and it has been designated as Paper 0 in the subsequent parts of this report. The moisture content was adjusted to a definite value by conditioning the sheets in an atmosphere whose temperature and relative humidity were controlled. For this purpose, a conditioning cabinet about 30 inches on a side was set up. A tray of saturated salt solution was placed in the bottom of the cabinet to control the relative humidity. A fan was used to circulate the air. Two thermostat-controlled 60-watt light bulbs were used to maintain a constant temperature of 92°F. The contactor of the Hart meter was removed and mounted inside the cabinet.

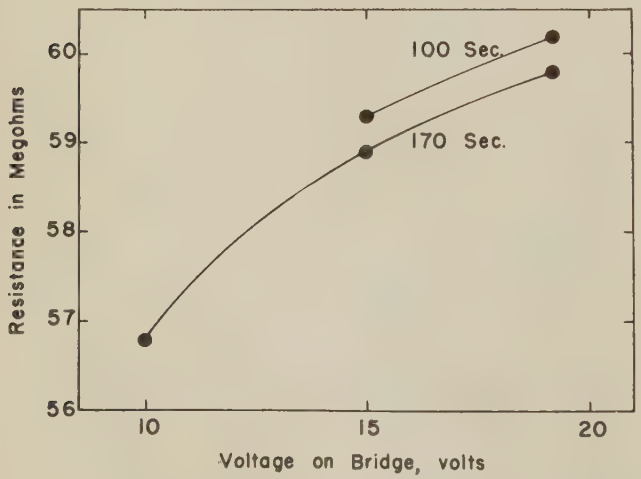


Fig. 11. A.c. resistance of Paper 0 conditioned at 39% R. H. vs. voltage on bridge

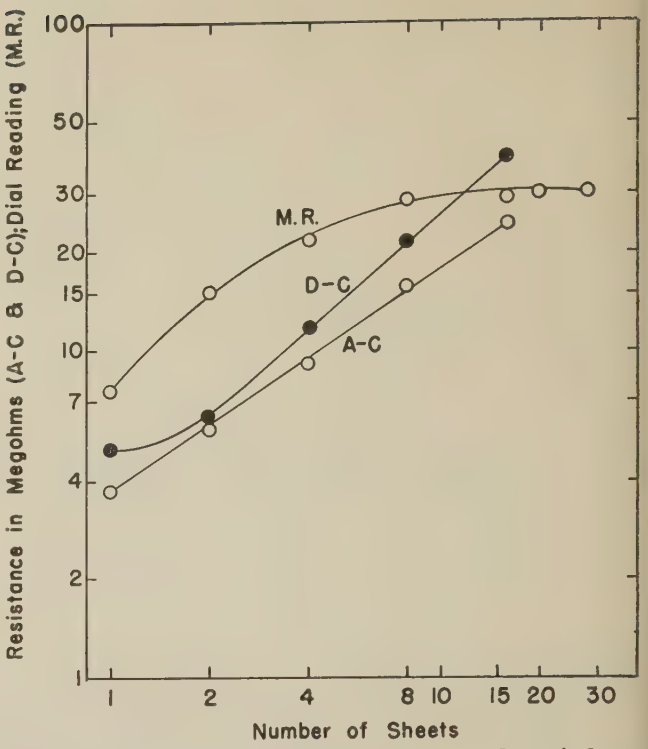


Fig. 12. Dial reading or resistance vs. number of sheets of Paper 0 for the Moisture Register, the d.c. vacuum-tube voltmeter, and the a.c. bridge

Well-insulated leads from it were run through one wall to a point outside, where connection could be made to the a.c., d.c., and Hart meter instruments resting on the table alongside the cabinet. Access to the chamber was through a 7-inch port covered with a removable steel plate—vision being through a double-glazed window above the port.

Each time the relative humidity of the cabinet was changed (by changing the salt in the tray), enough papers for the tests at this relative humidity were removed from storage in a desiccator and were hung in the cabinet for conditioning until ready for use. When a measurement was to be made, the port was opened, the paper quickly placed in the contactor, and the port closed again.

One of the first questions to arise was whether or not any given spot could be used more than once. There are almost certain to be some polarization effects with d.c. measurements and probably also some with the a.c. measurements, since the frequency was only 60 cycles per second. To determine the effect of polarization, tests were run at 21% relative humidity. Four spots on a sheet of Paper 0 were measured by the d.c. method; 1500 seconds later they were again measured and their resistances were found to be only about 70% of their original values. After another 1500-second period, these spots were again measured and their resistances were found to be only about 55% of their original values.

The Hart meter showed much the same sort of variations when the same spot was used repeatedly, although the effect was less noticeable as the instrument is less sensitive. These measurements were made with each of these instruments at one moisture content and, as will be seen later, the resistance may either increase or decrease with the application of the voltage to the paper. Because these variations are fairly large and

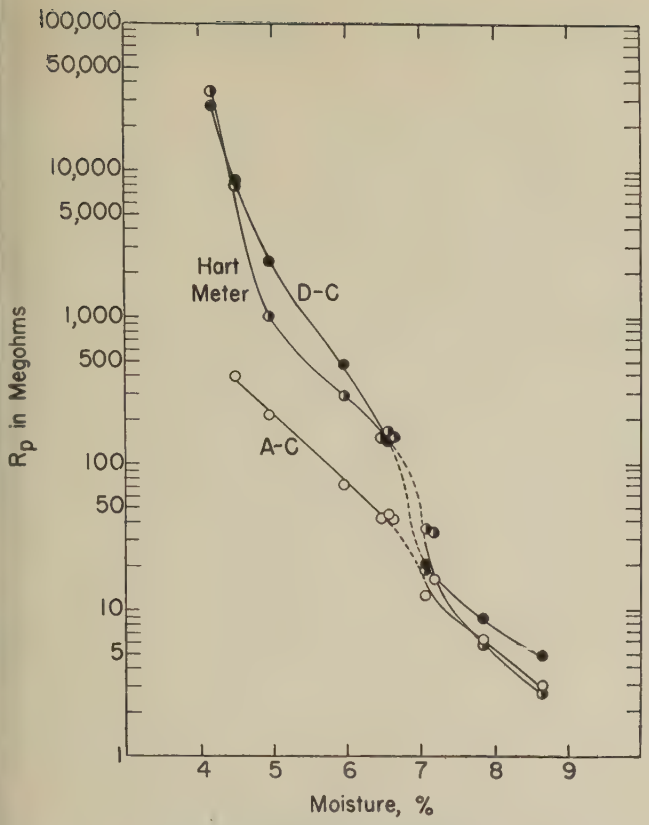


Fig. 13. Resistance of Paper 0 at 30 seconds vs. moisture content for the a.c. bridge, the d.c. vacuum-tube voltmeter, and the Hart meter

erratic, it was felt unsafe to use a given spot on the sheet more than once.

With the Moisture Register, however, there seemed to be no noticeable change in the dial reading when several readings were made on the same spot, except that, at the higher relative humidities, if a series of closely spaced readings was made, the second and all subsequent readings were one or two meter divisions lower than the first. If, however, the sample was allowed to stand a few minutes between readings, this decrease in reading was not observed. As a pad of paper is required for the readings with the Moisture Register, since the high-frequency field penetrates the paper to a depth of about $^1/_8$ inch, it was impractical to use a spot for only one reading with the amount of paper available.

For the next part of the general exploratory program, it was thought worth while to investigate the change in resistance of the paper resulting from such phenomena as polarization. To do this, a series of readings was made on the paper at various times after it had been mounted in the contactor—the voltage being applied throughout the measurements. These data were taken both with the d.c. and the a.c. instruments, and on papers conditioned in atmospheres at a number of different relative humidities. In order to present all the data on a common graph, the plotted resistance values are deviations from the resistance R_{1000}, measured 1000 seconds after the voltage had been applied.

The curves plotted from the d.c. measurements are shown in Fig. 8. It is seen that they are of two general types, those obtained with low relative humidities rising to a maximum and then falling off, whereas the curve for 59% relative humidity (R. H.) falls to a minimum and then rises again. At 52% R. H., the paper was in a sort of transition region, the curve having both a maximum and minimum. An attempt was made to explain the shapes of these curves, the most success being had with the curve for 39% R. H. This curve rises to a flat maximum at about 4000 seconds, and then falls slowly, this slow fall being linear within the limit of the experimental error. The paper was considered to be compressing or "creeping" within the contactor, this compression being slow enough for the resulting resistance change to appear linear. If this decrease in resistance caused by creep is subtracted from the curve, the curve which is obtained is very closely exponential; this is precisely what would be expected if the paper became polarized. Too much faith should not be placed in this "agreement," however, as it may well be fortuitous. It is reasonable to expect the behavior at 39% R. H. to be simpler than that at the higher humidities, as it has been observed frequently that the behavior of paper is erratic when moist; the curve at 32.5% R. H. then, should be similar to the 39% R. H. curve but it is not. Unfortunately, these curves were not all obtained with the same voltage (V_p) on the paper.

If the resistance changes are due to phenomena such as polarization, it is to be expected that these changes should become larger and occur more rapidly as the voltage on the paper is increased. This was confirmed by the data obtained (Fig. 9) for the d.c. voltmeter; all the curves for these measurements show a similar behavior, in that the resistance decreased somewhat at first and then increased. In these curves, the resistance is plotted against the time after application of the measuring voltage,[1] the various curves being for different voltages. For all the measurements, Paper 0 was used after being conditioned in an atmosphere of 59% R. H. The over-all change was much greater for the larger voltages and, also, the changes occurred much more rapidly. The resistance for the lowest voltage changed so slowly that the curve had not even reached its minimum in 1000 seconds, whereas the curve for the highest voltage reached its minimum in less than 100 seconds.

A set of curves of resistance versus time was also obtained with the a.c. bridge, as shown in Fig. 10.

[1] Curves of resistance versus voltage at various times would have been better but, unfortunately, the data were obtained in this form in the exploratory work.

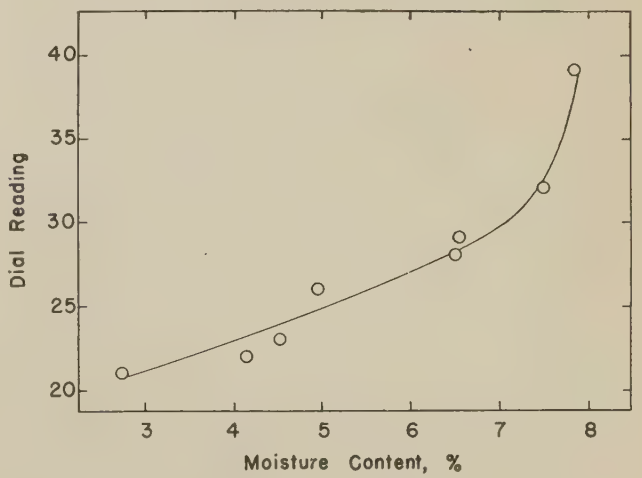


Fig. 14. Moisture Register dial reading for 20 thicknesses of Paper 0 vs. moisture content

The voltage (V_b) is that across the bridge but, as the voltage is across the resistance of the paper and one section of the resistance divider in series, and as the latter is less than 1000 ohms, this voltage is essentially that on the paper itself. These curves are simpler than those obtained by the d.c. method, and the total change in resistance is smaller. Here again, however, there appears to be some sort of a transition at about 52% R. H. The curves for lower humidities reach a stable value long before 1000 seconds, but the curve for 59% R. H. still continues downward at 10,000 seconds.

The effect of voltage was also investigated with the a.c. bridge, the results being given in Fig. 11. The resistances were obtained 100 and 170 seconds after the voltage was applied with three different voltages on the bridge, the two curves shown being for these two times. Paper 0 again was used, conditioned this time to a relative humidity of 39%. Once again the resistance decreased with time, as was shown in Fig. 10, but increased with the applied voltage.

It is quite likely that the electrical resistance of a sheet of paper will vary from spot to spot because of chance imperfections, such as conducting particles in the sheet. Hence, to partially average out the effect of these imperfections, it was decided to make all further measurements on two thicknesses; this was done for all further curves, unless otherwise indicated.

In order to obtain a rough idea of the variability of the data resulting from the instrumental error and from the variation of the resistance from spot to spot, the probable error of the mean was calculated by Peter's formula for measured values of the resistance of six spots on a double sheet. These calculations are presented in Table IV for the three resistance meters, and for sheets conditioned at seven different relative humidities. This error at 43% R.H. was larger than would be expected from inspection of the neighboring values. The explanation for this is not known. At 75% R. H. the a.c. and d.c. drifts were quite rapid, and it was more difficult to obtain a setting. Little drift was noted with the Hart meter; this is to be expected, however, since the sensitivity of the instrument is lower. The small error listed for this meter may be fortuitous, as the necessary calculations used for obtaining the resistance from the button readings are very rough for the lower resistances. It should be

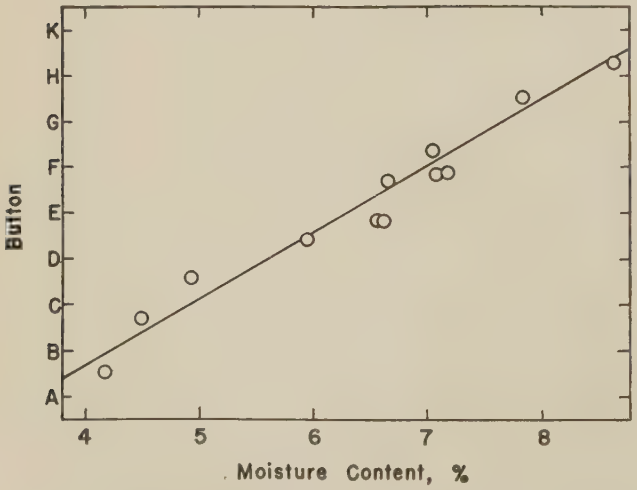


Fig. 15. Hart meter button vs. moisture content for Paper 0

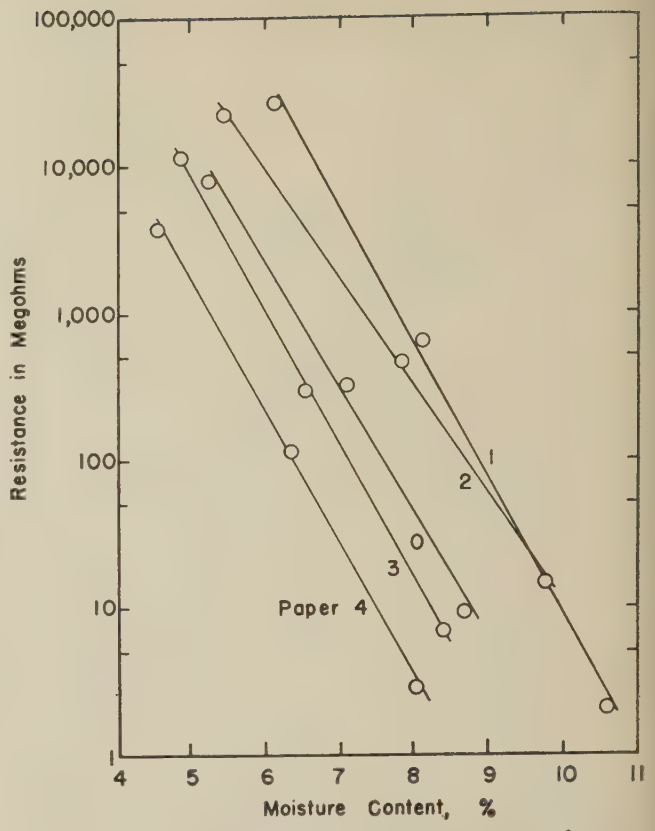


Fig. 16. D.c. vacuum-tube voltmeter resistance of papers at 30 seconds vs. moisture content

remembered that these error values are those of measuring the *resistance* of the paper—not its moisture content. From the curves of R_p versus moisture content of Fig. 13, the greatest error in moisture content caused by the resistance errors is only of the order of 0.03% moisture content. (This does not imply an *accuracy* of 0.03% for the method.)

It is to be expected that, as the number of sheets in the contactor is increased, the resistance should also increase, though not necessarily proportionally, since the contact resistance between sheets may be as important as the volume resistivity of the fibers. It was reported by Culver (*19*), for instance, that the resistance was nearly independent of the caliper of the single sheet. To explore this effect, a series of measurements was made with the a.c. and d.c. instruments on pads of Paper 0 from one to sixteen sheets thick, conditioned at 70% R. H. These data, plotted on logarithmic scales in Fig. 12, show nearly straight line relationships, indicating that the a.c. resistance varies with the 0.67 power of the number of sheets and that the d.c. resistance varies according to the 0.87 power. The d.c. resistance for a single sheet was somewhat higher than indicated by this relationship. It is quite

Table IV. Probable Error of Resistance Measurements on Paper

R. H., %	Probable error, % A.C.	D.C.	Hart meter
32	0.6	2.1	2.2
43	2.9	3.8	3.6
48	1.0	1.1	1.7
53	1.4	1.0	1.8
59	1.9	2.9	0.8
68	2.0	6.6	4.0
75	5.3	7.0	0.7

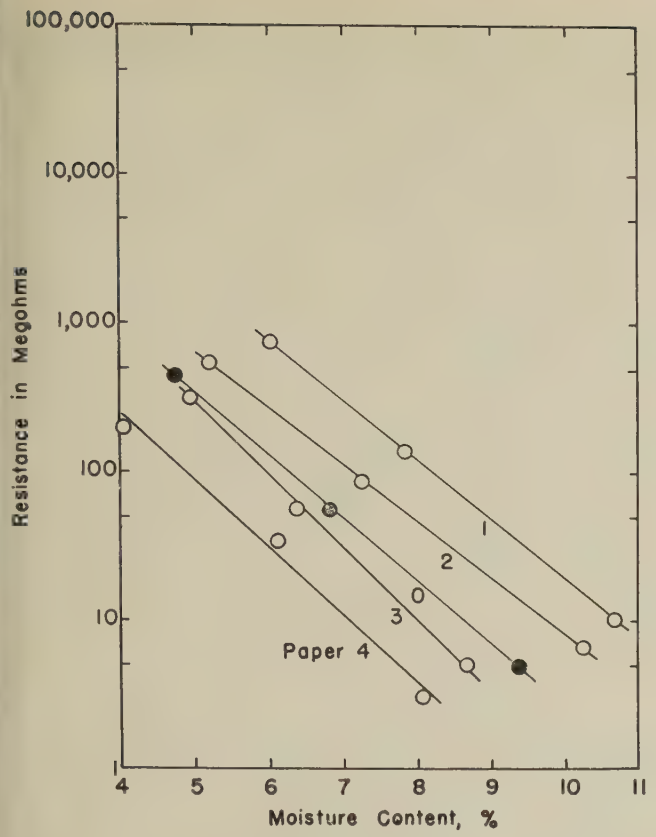


Fig. 17. A.c. bridge resistance of papers at 30 seconds vs. moisture content

probable that an entirely different relationship would result for paper conditioned at a different humidity.

Similar measurements made with the Moisture Register are also plotted in this figure. According to the manufacturer, the field from this model of their instrument penetrates to a depth of about $^1/_8$ inch, so that the paper should be stacked to this depth for measurements of the greatest accuracy. This is roughly substantiated by the curve, from which it is seen that the reading depends upon the number of sheets up to about 20, or up to 0.07 inch (the sheet caliper is 0.0036 inch).

An investigation was next undertaken of the variation of the resistance with moisture content, double sheets of Paper 0 being conditioned at various relative humidities over saturated salt solutions in the small cabinet. The data shown in Fig. 13 were obtained with the d.c. meter, the Hart meter, and the a.c. bridge. For each of these, the resistance was determined arbitrarily 30 seconds after the voltage had been applied on seven different spots on a double sheet. The first measurement was made merely to preset the circuit to an approximate balance so that the other six measurements could be made rapidly. The plotted values are the averages of the measurements on the other six spots. The voltage on the a.c. bridge was 9.7 volts; 25.0 volts were applied to the paper for the d.c. measurements.

At the completion of the electrical measurements at any one relative humidity, the sheets were torn in thirds. Two of the thirds from each pair of sheets were placed in separate weighing bottles. After weighing, the sheets were dried in an oven at 102°C. for 24 hours, weighed again, and the moisture content computed.

The average of the two moisture contents at each relative humidity is the value plotted.

Lithium chloride, giving a relative humidity of 11.1%, gave a moisture content of 2.76%. The resistance at this moisture content was so high that no balance could be obtained with the a.c. bridge, even with a standard resistor of 53,400 megohms. A reading was obtained with the d.c. method, which gave a resistance of 289,000 megohms, but this resistance is so high that it can hardly be called accurate. However, it does give some idea of the order of magnitude. No reading could be obtained with the Hart meter, as the resistance was higher than that of the highest reading button (A).

Potassium acetate gave a relative humidity of 20.4% and a moisture content of 4.17%, which was still so low that the resistance measurements were not reliable. As the humidity was further increased, the resistance versus moisture content curves were smooth for the three instruments, that for the a.c. bridge actually being a straight line on the logarithmic scale, until a moisture content of about 6.5% was reached, at which point sudden breaks were observed in all the curves. Beyond this point, the curves once more became smooth, the a.c. curve again being straight. Curiously enough, this break occurred at a relative humidity of about 52%, which is the same humidity at which the resistance versus time curves (Figs. 8 and 10) changed their character. The measurements were repeated on either side of the break to confirm the fact that the break was real and not the result of chance error in the data. No salt was known which would produce an intermediate relative humidity and intermediate points could not easily be obtained.

The effect of moisture on the electrical resistance of paper must depend a great deal upon the mechanism

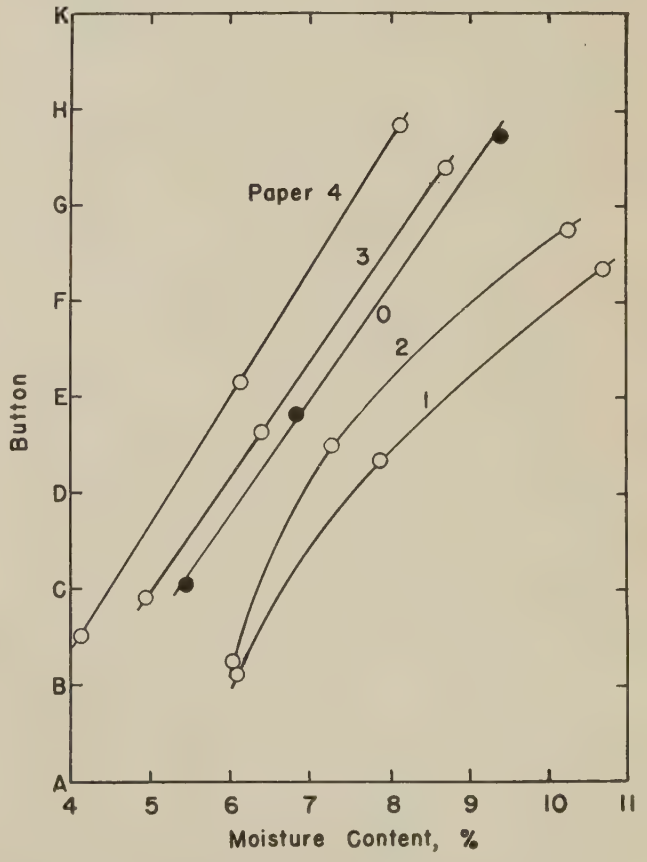


Fig. 18. Hart Moisture Meter button reading of papers at 30 seconds vs. moisture content

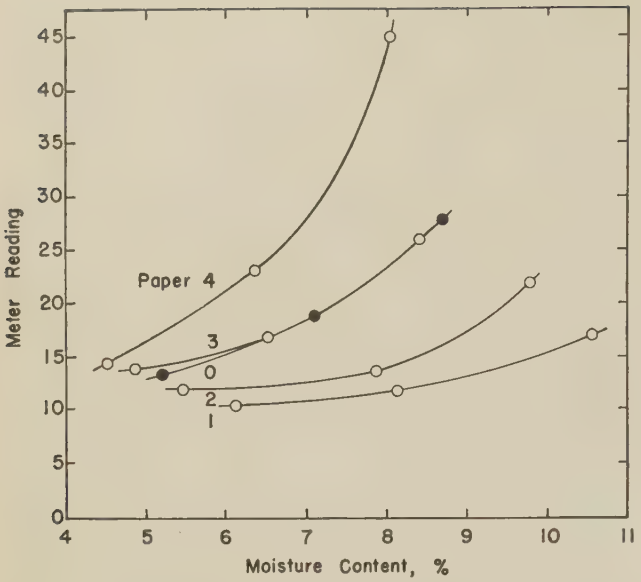


Fig. 19. Moisture Register meter reading for 7 thicknesses of Paper 0 vs. moisture content

by which the water molecules are bound to the fibers. At low relative humidities, the sorption seems to be a surface phenomenon (*23*) whereas, for higher humidities, additional moisture is held by capillary forces. The transition between these two, also, appears to occur in the neighborhood of 50% R. H.

The Moisture Register was obtained after a great deal of this exploratory work had been completed and the exploratory measurements with it were more limited in scope. It was not feasible at this time, for instance, to set up laboratory instruments to investigate the effect of moisture on the dielectric properties of paper. It was not expected that there would be any polarization effects as the frequency was high. Dielectric heating should be very small with such low available radio-frequency power. To confirm this, a test was run with 20 thicknesses of Paper 0 at 50% R. H. The correct pressure was applied and the oscillator was kept on for a period of 600 seconds, but no drift from the initial reading was observed.

A calibration curve for moisture with 20 thicknesses of Paper 0 was then run, as shown in Fig. 14. Over the major portion of its range, the instrument appears to be linear but, at high moisture contents, there is a definite deviation from linearity, which may be due to the fact that the circuit is approaching the point at which it goes out of oscillation. The manufacturer intended, of course, that the instrument should be used over a narrower range of moisture contents than those given in the figure. It is not essential, but merely convenient, that the calibration be linear. However, if nonlinearity should be an indication of instability, as it might be if the circuit is about to stop oscillating, the instrument will be inaccurate in that portion of the calibration.

A calibration curve has been obtained for the Hart meter, giving the moisture content versus push-button number, as shown in Fig. 15. In this case, the curve is linear within experimental error over the whole range.

SYSTEMATIC MEASUREMENTS ON REPRESENTATIVE PAPER TYPES

One of the more important phases of the program was that of determining the effect of variations in the paper itself on the accuracy with which moisture content measurements could be made with these instruments. If the Hart meter, for instance, when calibrated for use with a particular grade of book paper, were used to measure the moisture content of kraft, what would be the magnitude of the error if it were assumed that the same calibration curve held for both paper types? Some of these effects have been studied by Culver (*19*). As quite a number of variables in the paper manufacture were to be investigated, it was realized that the measuring technique would have to be simplified as much as possible. The use of a humidity cabinet was discarded because of the time required to open and close it for each determination. Instead, use was made of three conditioned rooms in the In-

Table V. Manufacture of Papers

Paper	Variable	Fiber furnish, %						Beating time, min.	Schopper freeness, ml.	pH		Alum, %	Size, %	Basis weight (25 × 40—500), lb.	Remarks
		Bleached sulphite	Unbleached sulphite	Groundwood	Unbleached kraft	Soda	Rag			In beater	In mold				
0	Standard	100	..	..	..	..	..	27	580	..	..	..	..	44.5	
1	Furnish	..	15	85	..	..	..	15	345	..	..	..	..	44.5	
2	Furnish	..	..	..	100	..	..	53	740	..	..	..	..	44.5	
3	Furnish	35	..	..	..	65	..	35	405	..	..	..	..	44.5	
4	Furnish	..	..	..	..	..	100	120	345	..	..	..	..	44.5	
5	Beating	100	..	..	..	..	..	20	740	6.5	..	..	..	44.5	
6	Beating	100	..	..	..	..	..	43	400	6.48	..	..	..	44.5	
7	Size	100	..	..	..	..	..	27	605	4.68	..	2	3	44.5	
8	Density	100	..	..	..	..	..	27	615	..	..	..	..	44.5	One pressing
9	Basis weight	100	..	..	..	..	..	27	615	..	..	..	..	139	
10	pH	100	..	..	..	..	..	28	590	4.24	6.68	7	..	44.5	
11	pH	100	..	..	..	..	..	28	590	3.38	4.86	35	..	44.5	
12	Ash	100	..	..	..	..	..	27	590	..	..	..	..	44.5	35% clay added
13	Dye, acid	100	..	..	..	..	..	27	600	..	..	2	3	44.5	8 lb./ton Quinoline yellow PEX, conc.
14	Dye, basic	100	..	..	..	..	..	27	610	..	..	2	3	44.5	8 lb./ton Auramine, conc.
15	Dye, direct	100	..	..	..	..	..	27	595	..	..	2	3	44.5	4 lb./ton Red 8BL

Consistency 1.57%; No. 4 Valley beater, 5500-gram bedplate load; British sheet mold used on all runs.

stitute, all at 73°F. and at relative humidities of 30, 50, and 70%. With all the apparatus and the paper out in the open, the measurements could proceed at a greatly accelerated rate. The measurements were limited, of course, to these three humidities.

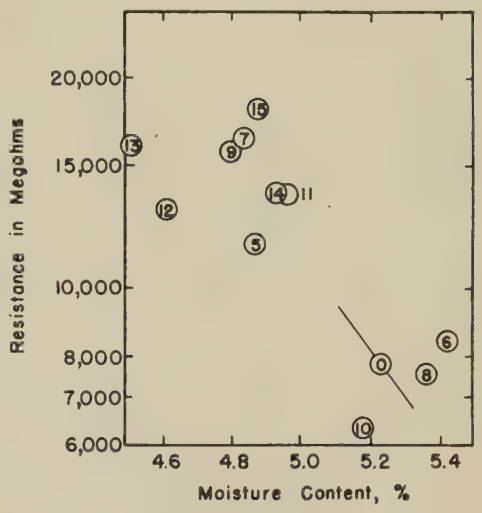
A series of handsheets was prepared by the pulping laboratory of the Institute, using TAPPI Standard T 205 m. They were made on the British sheet mold, but were not placed on templates. There were two pressings between blotters for all the sheets except Paper 8, which was given only one pressing. The sheets were dried for 5 minutes on the steam drier with 10 pounds pressure on the gage. Variables, including fiber furnish, beating, size, density, pH, basis weight, ash, and dye, were introduced in their manufacture, as it was thought that these factors might have some effect on the electrical resistance of the paper. The handsheets made of 100% bleached sulphite (Paper 0) were chosen as standard, and were used as a basis for comparison of the other sheets. The data on the above variables are given in Table V.

To supplement the factors known from the method of manufacture of the paper, determinations of ash, density, basis weight, and fluorescence size time were made; the results of these tests are given in Table VI.

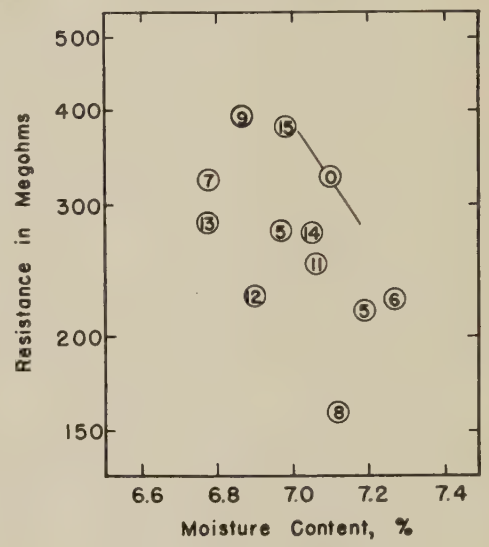
The technique of measurement was similar to that used earlier. The paper was first desiccated over calcium chloride, and then conditioned for several days in the 30% humidity room before the measurements were made. The remaining sheets were then removed to the 50% humidity room for those tests; the remainder were placed in the 70% humidity room for the final series of measurements. Variations in the observed oven moisture content of a particular paper when conditioned at the "same" relative humidity for the four instruments may be attributed to the fact that the tests at any one relative humidity extended over a period of a least two days, during which time the relative humidity did not remain fixed at its nominal value.

Double sheets were used throughout the a.c., d.c., and Hart meter determinations. The average resistance of six spots taken on each double sheet was taken as the resistance of that particular paper at that humidity and for that type of measurement. No spot was used twice. For the Moisture Register instrument, seven sheets of each type of paper backed with a 1/4-inch piece of polystyrene were used. It would have been better to use more sheets but they were not available. From Fig. 12, it can be seen that the error introduced by this is small. As the measurements were comparative and not absolute, this error tends to cancel out. Four spots were measured at each relative humidity. These same spots were used at each humidity, but no spot was used twice at any one humidity.

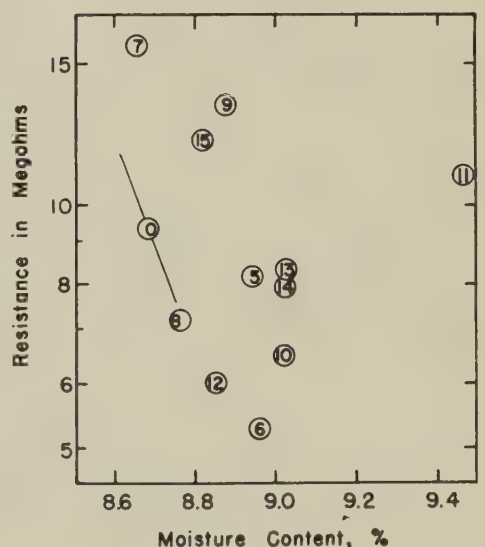
From preliminary plots of the data obtained, it was evident that the variable having the most important effect on the electrical properties of the sheet was the fiber furnish. The measurements on the four sheets with variable fiber furnish and on the standard are plotted in Fig. 16 for the d.c. voltmeter, in Fig. 17 for the a.c. bridge, in Fig. 18 for the Hart meter, and in Fig. 19 for the Moisture Register. In all these graphs, the abscissa is moisture content; for Figs. 16 and 17 the ordinate is the paper resistance; for Fig. 18 it is the Hart button number and, for Fig. 19, it is the Moisture Register dial reading. From the figures it is evident that there are rather large variations



(a) Conditioned at 30% R. H.



(b) Conditioned at 50% R. H.

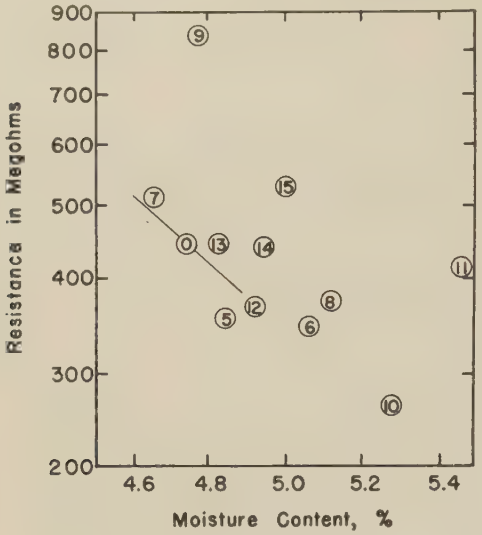


(c) Conditioned at 70% R. H.

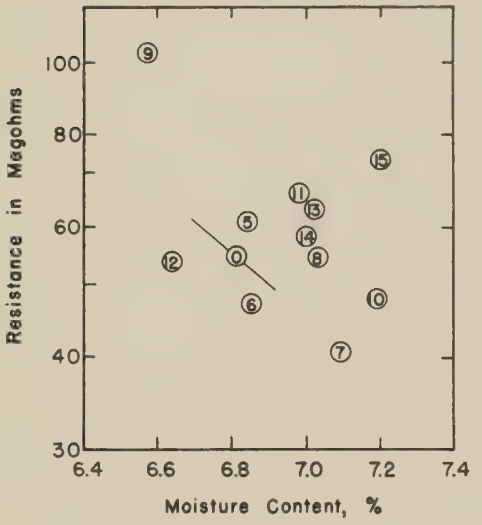
Fig. 20. D.c. resistance vs. moisture content of papers as numbered

both in the moisture content and in the resistance from type to type. The curves in the first three figures are roughly parallel. If the curve for Paper 0 were assumed to hold for all types, there would be an error in some cases as large as 2% in the moisture content determination. Hence, a separate calibration curve must be run for each type of paper.

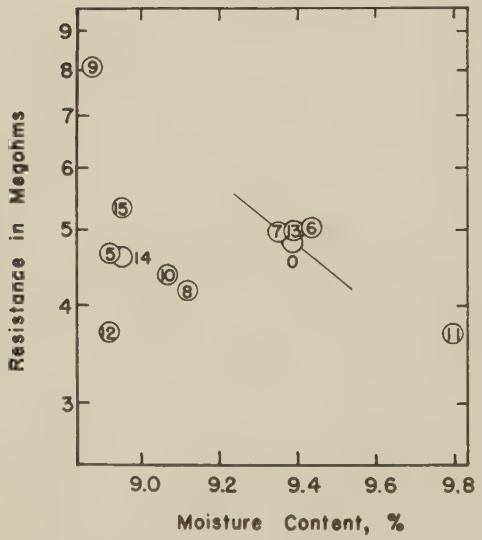
The curves for the Moisture Register (Fig. 19),



(a) Conditioned at 30% R. H.

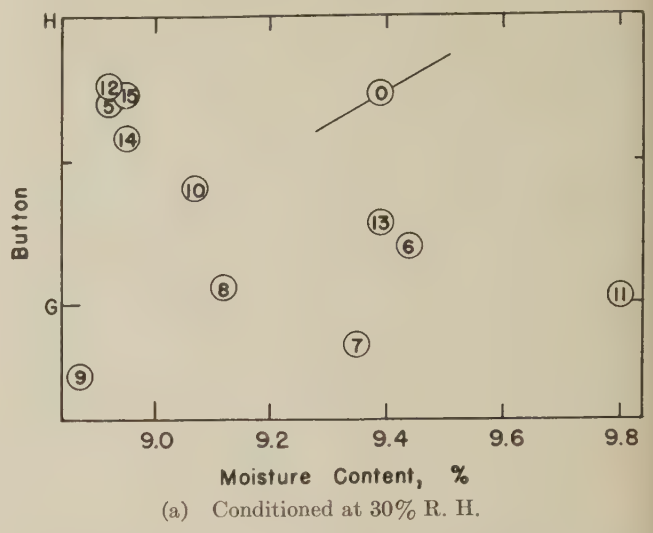


(b) Conditioned at 50% R. H.

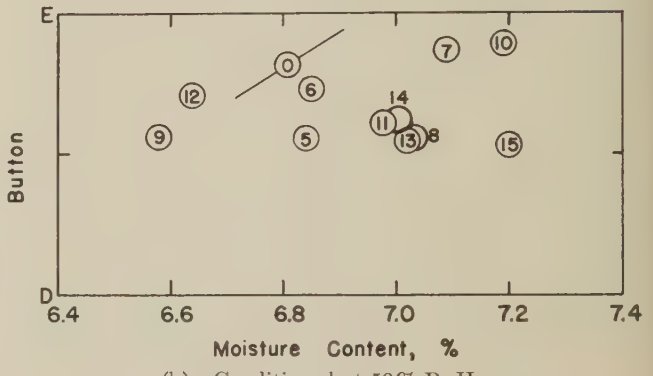


(c) Conditioned at 70% R. H.

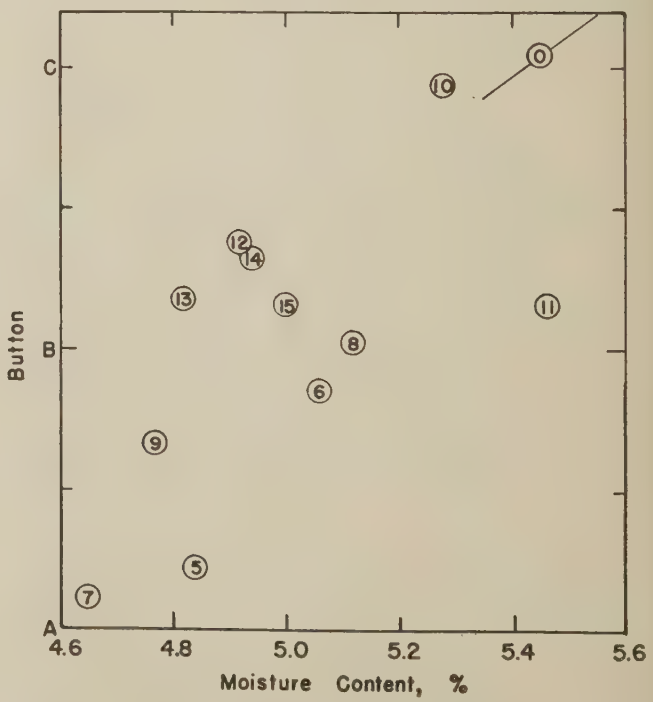
Fig. 21. A.c. resistance vs. moisture content of papers as numbered



(a) Conditioned at 30% R. H.



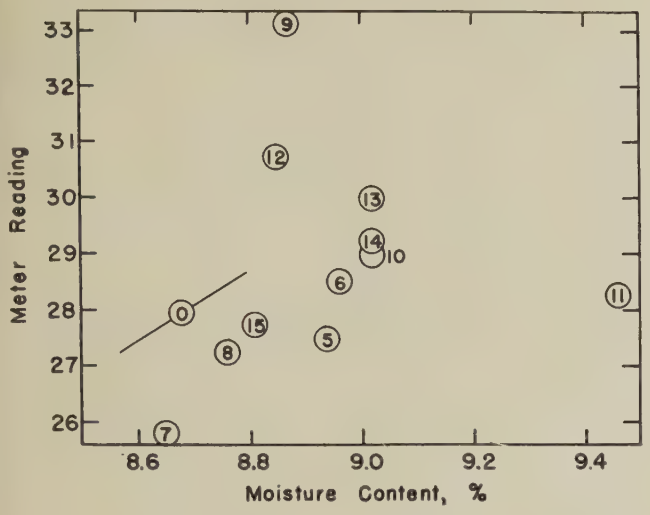
(b) Conditioned at 50% R. H.



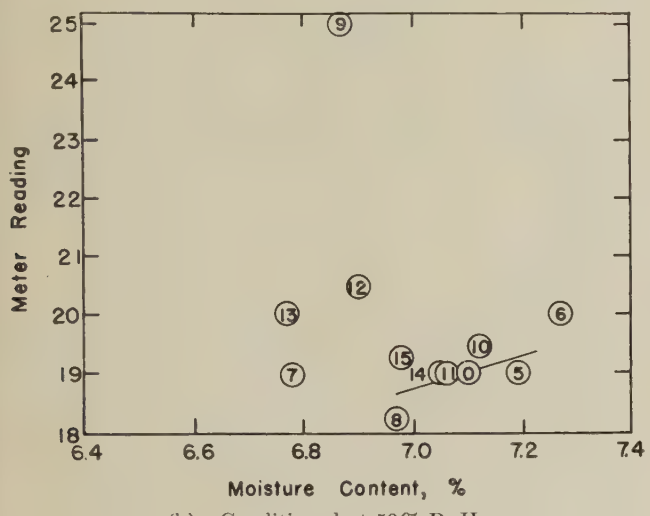
(c) Conditioned at 70% R. H.

Fig. 22. Hart meter button vs. moisture content of papers as numbered

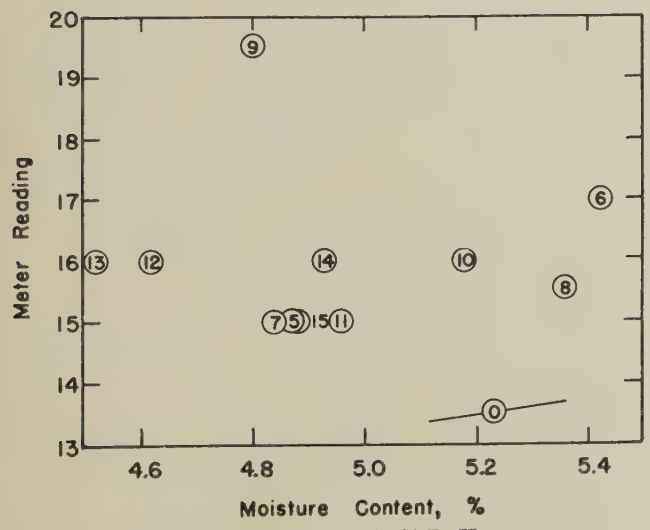
however, are definitely not parallel, nor are they approximately straight lines. There is a rather large difference in the sensitivity of the instrument, the larger change in moisture content of the groundwood sheet (Paper 1) causing a change of only about five divisions in the meter reading, whereas the smaller



(a) Conditioned at 30% R. H.



(b) Conditioned at 50% R. H.



(c) Conditioned at 70% R. H.

Fig. 23. Moisture Register meter reading vs. moisture content of papers as numbered

Table VI. Properties of Papers

The Handsheets Were Conditioned and Tested at 50% R. H. and 73°F.

Paper	*Basis weight (24) (25 × 40—500), lb.*	*Caliper (25) in. × 10⁻⁴*	*Apparent density*[a]	*Fluorescence size (26) time, sec.*	*Ash (27)*[b]*, %*
0	45.6	36	12.5	4	0.5
1	46.2	50	9.0	5	2.5
2	47.2	45	10.5	4	0.9
3	44.7	35	13.0	3	0.5
4	44.9	37	12.0	2	0.5
5	46.8	39	12.0	3	0.4
6	44.7	34	13.0	3	0.5
7	46.0	38	12.0	39	0.6
8	46.4	39	12.0	3	0.3
9	141.5	100	14.0	4	0.3
10	46.8	38	12.5	3	0.9
11	47.8	38	12.5	2	2.7
12	46.2	37	12.5	2	3.9
13	46.2	38	12.0	50	0.6
14	47.0	39	12.0	67	0.5
15	45.5	37	12.5	55	0.5

[a] Apparent density (reported to the nearest 0.5 unit) = basis weight/caliper (0.001 in.).
[b] Oven-dry basis.

moisture content change in rag sheet (Paper 4) causes a change of 30 divisions in the meter reading.

The Moisture Register would appear to be entirely unreliable for measurements on groundwood and unbleached kraft because of its low sensitivity. The manufacturer claims, however, that the instrument can be adjusted to cover any desired range.

The effects of the other variables (Papers 5 to 15) are smaller, nearly all the measured points for these sheets falling between the curves for Papers 2 and 3 in the figures just discussed. In order that the variations might be more clearly presented, the data on these sheets are plotted on an enlarged scale in Figs. 20 through 23, one for each of the three moisture contents, for each of the four instruments. The coordinates used are the same as for the corresponding previous figures.

The moisture content and instrument to which each figure pertains are given with the figure. On each of these figures, the point for Paper 0 has been repeated, a line being drawn through this point with the same slope as in the corresponding Figs. 16 to 19. The deviation of a particular point from this line is the amount by which the calibration curve for Paper 0 would be in error when applied to this type of paper. The advantage of having a separate calibration curve for any special paper type can be estimated from this deviation.

CONCLUSIONS

Probably the most important development from the more fundamental part of this investigation is the apparent connection between the irregular behavior of the electrical resistance of paper in the neighborhood of 50% R. H. and the transition observed by others between surface and capillary sorption of moisture at this humidity.

A few remarks can be made regarding the electrical resistance and the dielectric loss methods of measuring the moisture content of paper. The former appears to be more reliable when the moisture content is high and the resistance is low than it is for low moisture contents. The measurement of very high resistances of paper has been extended about to the safe limit in the Hart Moisture Meter. The dielectric loss

method, on the other hand, appears to give its most reliable readings on low loss, high resistance papers—that is, low moisture content sheets. If too much loss is introduced in the oscillating circuit, it should not be stable. Adjustment of the circuit constants of the Moisture Register, however, should enable it to be extended to cover almost any range. For instance, the tightness of coupling of the contactor to the resonant circuit would control the effectiveness of the moisture content in decreasing the amplitude of oscillation.

The Hart meter readings should be nearly independent of the condition of the tube and batteries, since the resistance of the paper is compared with the resistances of standard resistors in the meter. These resistors should be stable as long as they are not subjected to too high temperatures or too much moisture. There should be no overheating from the normal voltages applied to them. Measurements were made to determine the effect of a short-term exposure to high relative humidities, no appreciable drifts being detected. A long exposure to high humidities at high temperatures, such as might be experienced in a southern paper mill in the summertime, might cause an appreciable drift, however. As mentioned earlier, if the tube developed an appreciable grid emission, an error would be introduced in the low moisture content, high resistance end of the calibration curve. Wearing out of the plate supply battery should have a small effect on the measurement since the resistance of the sheet varies with the applied voltage. This effect is small, being of the same order of magnitude as the variation of the resistance from point to point on a given sheet. More important than this would be loss in sensitivity of the instrument if the plate-battery voltage fell too far, which, it is felt, would be noticed long before the above resistance change became large enough to be significant. The filament voltage has a large effect on the sensitivity of the instrument but, of course, little effect on the reading obtained.

Unfortunately, no materials are available whose dielectric loss can be standardized. The Moisture Register is forced to rely on the stability of the circuit itself to maintain the shape of the calibration curve. Most of the drift which normally occurs in a vacuum tube circuit is balanced out, however, by means of a "zero" adjustment, the meter being brought to full-scale deflection (zero reading) with the contactor held away from the paper. Actually, the moisture in the air and that adsorbed on the contactor introduce a small amount of loss which can affect the zero adjustment. The gun of this meter was moved between two regions in which relative humidities of 60 and 10% were maintained; this change in the humidity caused a drift of about one-half division in the zero reading. This drift is no larger than the error which might normally be introduced in adjusting the zero. At very high humidities, however, this effect might be considerably larger. The resistances in this meter are all much smaller than those used in the Hart meter and, hence, drift in their values resulting from high humidities would be small. The circuit has been ingeniously arranged so that drift in the "B" battery voltage should cause no error in the meter reading, since this voltage is applied through the zero adjustment potentiometer to both the grid and plate circuits. As the battery voltage falls, this potentiometer is merely turned a little higher. Filament voltage variations, however, cannot be balanced out, though they tend to be compensated for by the zero adjustment.

Mechanically, both instruments are ruggedly enough built to meet ordinary use requirements. The connecting cable between the two units of the Moisture Register was found to be a weak spot. Twisting the cable where it enters the gun caused the meter deflection to vary in an erratic manner. A special clamp visible in the photograph of the instrument was added to hold the cable from twisting at this point, thus eliminating the trouble. The manufacturer now clamps this cable firmly.

As recommended by the manufacturers of the two instruments studied in this investigation, separate calibration curves should be obtained for each furnish and type of paper. This has been shown to be especially necessary where the fiber furnish is varied. For best results, the circuit constants of either instruments are so chosen by the instrument manufacturer to yield optimum results for the particular grade of paper of greatest interest.

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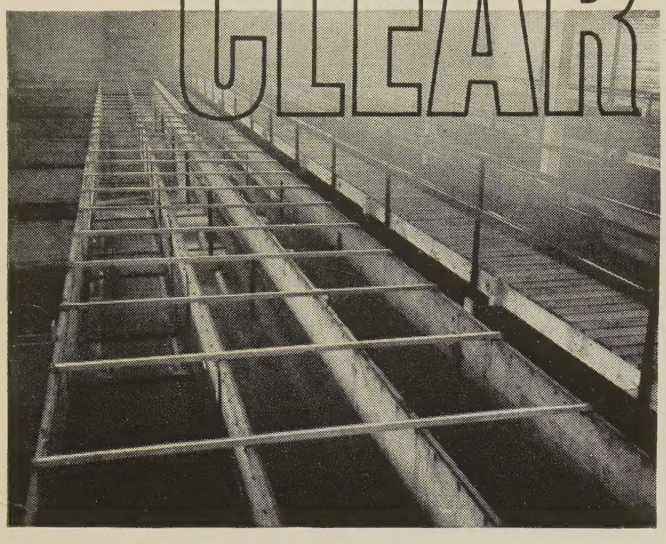

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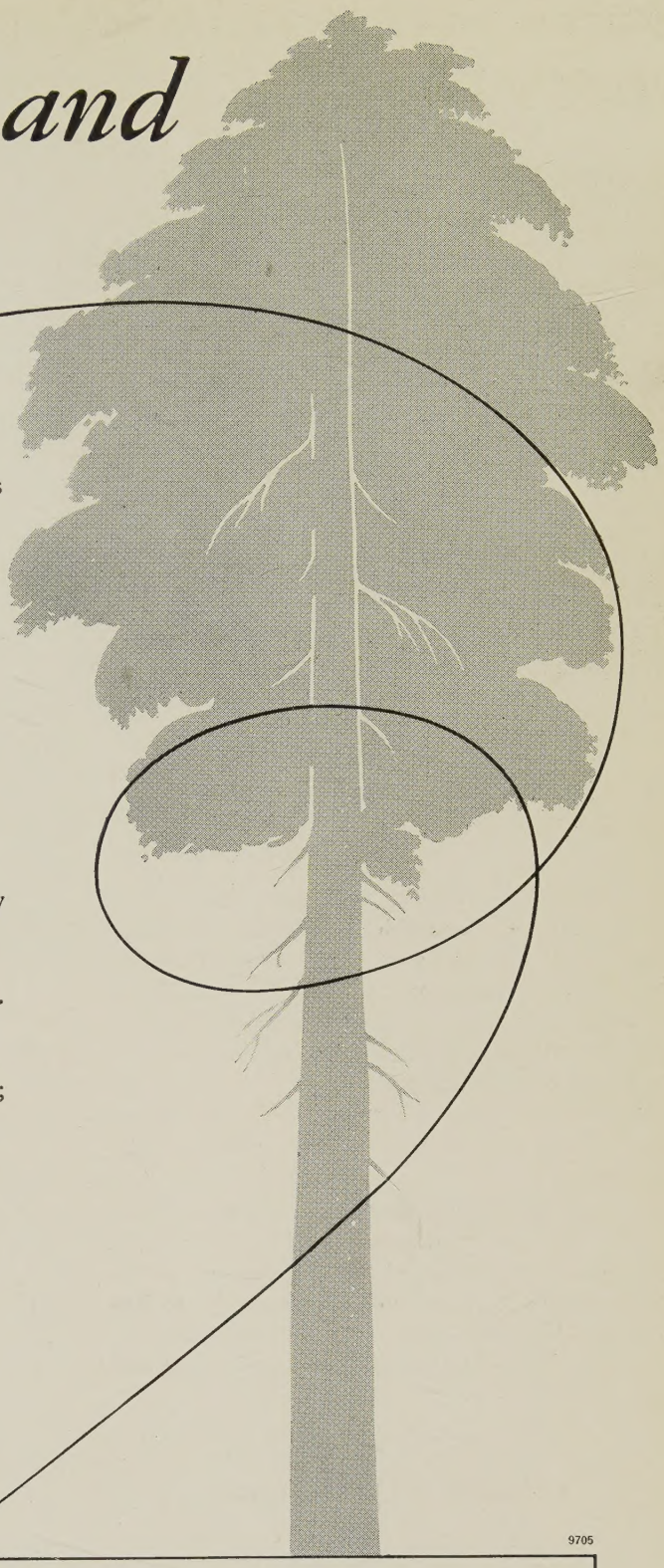

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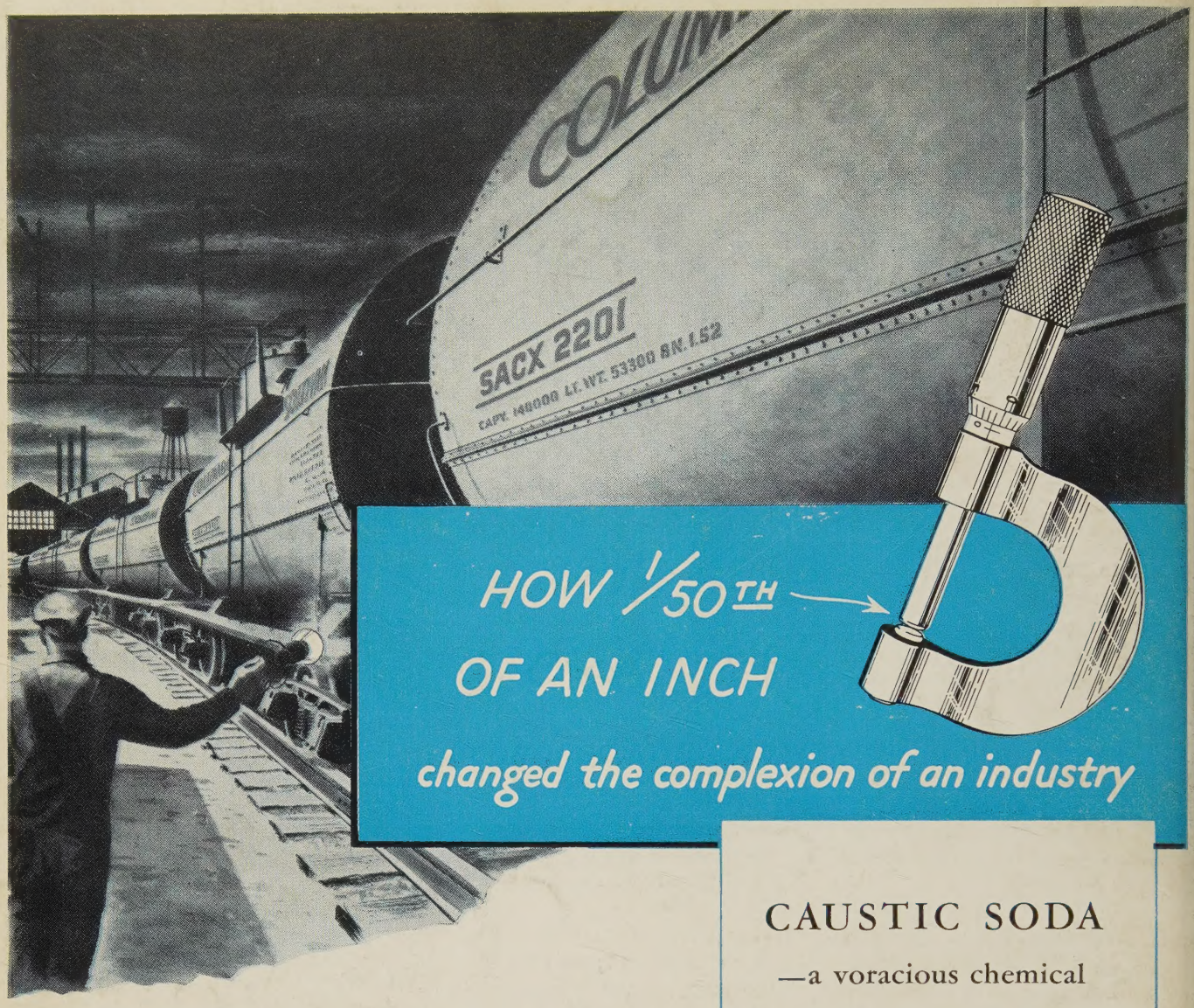

HOW 1/50TH OF AN INCH changed the complexion of an industry

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